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THE PINE SNAKE OF NEW JERSEY.

BY REV. SAMUEL LOCKWOOD, PH.D.

In the "pines" of southern New Jersey, which probably is the northern limit of the species, is a notable serpent, reputed to attain the great length of nearly twelve feet, and whose body is then, in common parlance, "as thick as your arm," or in more moderate speech, from three and a half to four inches in diameter. Not that the writer has seen any of such dimensions, but he gives what may be called the mean of popular observations. This reptile has a shiny coat of a soft creamy white, upon which is laid, much in the Dolly Varden mode, showy mottlings or blotches, which, beginning at the neck, are of an intensely dark brown or chocolate color, but which toward the tail lighten up into a pale bright chestnut. Such is the pine snake; and its habitat and traits are well expressed in the beautifully significant name which science has given it — *Pituophis melanoleucus*, which literally means, "the black and white serpent of the pines." If one consider the formidable size it is said to reach, together with its notably harmless nature, and the splendid adornings of its scaly armature, distinguished mention must be made of this reptile, as the most remarkable serpent of the Eastern States.

The first time I saw the pine snake alive was eighteen years ago. I was on the steamboat going from Keyport to New York. It was the berry season, and persons from the pines were on

board taking their eggs and "huckleberries" to the city market. The Pines, so called, had not up to that time been visited by me. "Forrard" of the boat, being the place where the hucksters, farmers and fishermen most did congregate, was a sudden and unusual commotion. One solitary woman held her own in this crowd of men. She was from the Pines, and in her way was an intensely thorough-going business body. She had a wagon-load of eggs and berries, which latter she had bought of the pickers, and on them she expected to "realize" handsomely. The assistant captain, an elderly and corpulent man, was collecting the fare. Approaching the female huckster, whom he knew well, he accosted her with "Come, Peggy, your fare." "Yes, Cap'en, but jist hold my comforter till I git my pus out." And in a trice a pair of pine snakes, concealed beneath the woman's shawl, were slung around the captain's neck. The old man's example was electric! Such accelerated evolutions! It seemed neck or nothing with everybody but the huckster woman, who sat shaking with laughter. She had retained hold of the reptiles by the tails, so that they were left in her hands. She was taking them to Barnum, who probably would give her a few shillings, and a few tickets to his show. Prof. Baird had just before requested me to get a pair of these reptiles for the Smithsonian. My mind was made up that these should go to the Professor. At this juncture a fisherman whispered into the woman's ear, "Keep your eyes skinned, Aunty, a science man 's around." The woman became at once very exacting. I bought the pair at an unreasonable price; but an accident prevented their ever seeing Washington. They were of both sexes, I think, and were about three and a half feet long. Their harmlessness surprised me. Even my little children played with them. Indeed the late Prof. Torrey, a good many years ago, had a pair that were allowed the freedom of his study floor. The female of my pair laid seven eggs, each about five-eighths of an inch long. From their size they must have been premature.

Three summers ago a friend captured a fine female specimen and sent me. It was in good condition, nearly six feet in length, and as thick as my wrist. To my surprise the beast was incorrigibly irritable, and kept up a vicious blowing, and darting at me, each time hitting her nose against the glass cover of her box, so that, much to my grief, she knocked off the hard scale on the tip of her snout. The cause of this unexpected conduct was not far

to seek. The poor thing had the cares of maternity coming upon her. On the 18th of July she laid twelve white eggs; and a beautiful sight did they present. There were two clusters, the eggs adhering to one another. Two of the eggs were under the average size. These seemed to have been laid first. There was one still smaller which seemed to have been laid the last. In one of these clusters were seven eggs and in the other five. I was astonished at their size. A single egg measured twenty-two lines in length, and sixteen in width. They were in fact as large as the eggs of an ordinary bantam fowl. One of them weighed 543 grs., and the whole weighed about fifteen ounces avoirdupois. They were of nearly the same form and size at each end, except that at the upper end, or the end last evicted, was a little cusp, or teat-like prominence, precisely such as characterizes the fossil coprolites, and due to the same cause, the nipping off, or closing up of the cloaca, as the egg in its soft condition passed out. The eggs at this precise moment must be quite soft, as they were agglutinated together side by side. An attempt to separate a pair succeeded in pulling off a portion of the shell which adhered to the other egg. In this regard the resemblance to insect eggs was striking. The shell had a fine and pretty marking, as of reticulation.

An attempt was made to hatch the eggs, but without success. They were put in a box of sand, which was moistened, and every effort made to preserve the proper temperature by keeping it warm; but the eggs perished. It is curious that in all my inquiry of the old settlers in the Pines, I have learned nothing about the eggs of the pine snake, — no one, so far as I could ascertain, had ever seen them.

It is interesting to observe the pine snake drink. It lays its head usually flat upon the water, letting the lower jaw just sink a little below the surface, when with a very uniform movement, the water is drawn up into the mouth and passed into its throat. It is the same as the drinking of a horse; that is, it is a true drinking. With a snake, lapping is an impossibility; the form and position of the tongue are unsuited for such an act. The tongue of a serpent is like a flattened cord, divided at the forward end into two pointed threads as soft and flexible as silken fibres. This delicate organ is projected from a round orifice in the middle, and somewhat forward of the trough or hollow of the lower jaw. And

a very beautiful functional arrangement all this is: for as might be conjectured, when swallowing its prey entire, the tongue must be put out of the way. In this emergency it actually disappears from the mouth altogether, being withdrawn at the orifice mentioned. Drinking, with the pine snake, is a slow affair. I have several times watched it by the clock. Once it drank exactly five minutes without taking breath. It then paused, looked about for three minutes, and went at drinking again, occupying precisely five minutes as before, thus making ten minutes. The amount of water drank was a little over a gill. Previous to this drinking she had been without water four weeks.

The reptiles have seemed to me specially to be capricious and fastidious about feeding in confinement. The pair of small pine snakes mentioned at the outset ate young chickens just from the nest, but would not touch mice. My large one for a whole month after laying her eggs had not eaten anything. A young chimney swallow was given her, but, though the little thing fluttered and cried, she took no notice of it. A young chick three days old was offered, nor would she notice it. Both birds were removed unhurt, in fact, untouched. A rat with a limb broken by the trap was next put in her box. Her attention was at once aroused. After looking intently at it for a minute, she made a sudden dart, striking the rat on its side with her nose. With a squeak, the poor thing turned its face towards its grim assailant. The latter with head erect, but motionless, and tongue quivering, kept its eyes steadily on its victim. There was a sudden spring, and the rat's nose was in the grip of the monster's mouth. Quickly, but deliberately, the snake held its victim against the side of the box; then setting the sharp edge of each of the long scuta or abdominal scales on the floor, as a fulcrum, brought a part of its body, like the convex side of a strong bow, against its prey, forcing it to the side of the box with a compression that made the bones of the rat give a crackling sound. The suffering of the victim was but for a moment, as I have no doubt that the spine was broken instantly. Although the prey was quite dead, there was still that singular deliberation, and several minutes elapsed before that compression was relaxed. Quietly now the snake began the act of swallowing its prey. It commenced with the head. The action of the creature is very interesting. It is not by a uniform movement of the entire prey that the swallowing is performed. The snake opens

its mouth widely on one side, and then gives a slight hitch with its outer teeth, or the teeth on the opened side of the mouth. This done the mouth is kept closed on that side of its prey, and the other side of the mouth is now opened, and the same hitching gone through; and so the action is alternated, the hitching being about two minutes on each side by turn. It is pretty much as if the finger of a tight thread glove should be drawn on by using the nails of a thumb and finger successively on the sides. This is a beautiful mechanical movement, by which the force applied is admirably economized, a prime consideration when food in a mass much larger than the head and neck of the snake is to be passed entire through the gullet. The swallowing is so extremely slow that the movement is practically imperceptible. With watch in hand I found when the hind legs of the rat disappeared twenty minutes had elapsed since the swallowing began. The tail of the prey is the last to disappear. But in the final movement the mouth of the snake takes no part. The body having passed the gullet there is a vigorous muscular action along the long thorax. To our astonishment we now heard again that singular crepitating sound which resembled the breaking of the bones; could it be the breaking of the ribs? In slowness of eating and drinking our ophidian fulfils strictly the precept of the most exacting hygienist. But what about the breathing for those twenty minutes during which the entire throat was closed as tightly as the wadding stops up a gun? Surely for the time being respiration was absolutely checked. As if to make up for this estoppel of its breath, the creature is now gaping so widely that a fine opportunity is afforded to inspect the interior of its mouth.

A fact observed here, as also when I fed the smaller ones with birds, was that the snake did not beslime or lubricate its victim before swallowing. I had expected to see this, for I once caught a large black snake, *Bascanion constrictor*, robbing a nest of young birds. The nest was in a hummock of grass in a swamp. It had two birds on the ground, one of which was literally enveloped in white slime, like a fly in a cobweb, and the other was in process of lubrication. Unfortunately the snake saw me, and the process was stopped, as the animal now tried to escape.

By the old settlers in the Pines, this reptile is often called the bull snake, because of the remarkable sound it makes when blowing. A case was told me of a large pine snake being captured by

a farmer's boy, who tied a string around its tail, and having taken it home, tied the string to a small bush near the kitchen door. Not intending anything, the boy said nothing about it. As the family were at supper, the snake commenced blowing. This was heard by the good mother, who cried out, "There, that bull's got into the corn field again!" The boy broke into laughter, and then told what he had done. And well do I remember my boyish terror at hearing a similar sound. It was the restrained bellowing of a bull, which came upon me suddenly in a field. There is nothing sibilant in this blowing of the pine snake, not the slightest hiss about it. The animal slowly fills its long thorax with air, and then expels it with a bellowing which is really formidable.

Observations made on an animal in confinement should be weighed accordingly. A fact given me by an old resident in the "Pines" would indicate that the pine snake is a great feeder. He said he saw one killed, out of which were taken two young rabbits and twelve quail eggs (the eggs may have been her own). This snake likes to get under barns, without doubt in quest of rats and mice. But for the above statement, I might have inferred from my specimen that the species is a moderate feeder, as it often refused food offered it. About a week after the swallowing of the two rats I put a live one into the snake's box. She was not hungry, and was evidently annoyed by the rat's presence. So she made a dart, striking it on its side. The rat, plucky in its terror, turned upon and bit its assailant. This was a new experience to the reptile, and momentarily dazed with incomprehension of the situation, it recoiled upon itself. It was, however, beside itself but for a moment, for it instantly became alive with subtle action. The tongue quivered with excitement, and that living cable, which made up those fearful coils, began a rapid thickening. The creature seemed to be inhaling air down its whole length. Now began that fearful blowing. It was truly a bellowing of snakish rage, and was followed up by a savage dart at the innocent intruder, which gallantly returned the compliment with another nip of its sharp teeth, sending the snake back in haste to the farther corner of the box. I noticed that the rat was in nowise stupefied, or affected in any way corresponding to the so-called fascination of serpents. Keeping its head raised, eyes fixed and tongue quivering, the snake filled with air again; then again

came that appalling sound, and another dart, with the same response from the rat. I cannot depict the seeming tussle of each round. It was not so much on either part an effort to close in, as it was to deliver its own shot, and then get out of the way, so that on the part of the snake each charge received caused a squirming that looked like a wild beating of the air. She went at the poor rodent again and again. Matters were waxing desperate. The rounds were quicker and more severe. There was less blowing and harder fighting. I was now desirous to separate them, but knew not how to bring it about. The truth told, I was getting to be somewhat nervous about the personal appearance of my beautiful serpent, which seemed in great peril of bodily damage. At last both combatants seemed sick of their bargain. So there was a temporary truce, which intermission of hostilities, as it often is with wiser bodies, was made the opportunity of a mutual effort to escape, the rat inspecting every part of the box, and gnawing at every crevice; the snake butting her nose in vain attempts to break through the glass. The truce lasted ten minutes. The rat was sitting quietly in a corner cleaning its face with its paws. The snake had ceased its vain darting at the glass cover, and, as if for rest, had spread itself over two-thirds of the floor of the box. It seemed as if a fair understanding had been reached, and that hostilities were really at an end. It was a treacherous calm. Incited by some cause the rat made a run for the opposite side of the box. Alas! this movement was the one fatal error of this little hero's life. In attempting this, it had to cross over a portion of its enemy's body. It was the merest touch, but that touch was death. Instantly every particle of the serpent's body flashed into activity, as if the whole had been powder, and a spark of fire had fallen on it. In the merest fraction of a second of time, the reptile that seemed to be lying so languid was transformed into an inverted nest, under which was the poor rat. I looked for the head of the snake. It was under this living nest, holding at the hinder part its victim, which was doubled up in this strange compression. And stranger still was the wonderful adjustment that a half minute of time sufficed to accomplish. The inverted nest of coils opened at its upper or convex end, like the crater of a miniature volcano. Out of this was evolved the head and front feet of the little rodent, whose dark lustrous eyes stood out and neck grew thick from the fearful compression. As the

pretty little flesh-colored hands lay upon that fatal upper coil, it did so look like the intercession of helpless suffering with pitiless power! This terrible constrictor, although the act was done in an instant, had fully exhausted all her ingenuity in throwing up this fearful engine of strangulation. It was not merely a series of nest-like constricting coils, but one great coil went transversely over all the others; as when the hand squeezes a lemon, and the other hand is made to help the compression. One could hear the bones crack! All this time the head of the serpent is underneath, holding its little captive in place, while that spiral vise squeezes out the brave little life that has so stoutly held its own against such odds in a mortal combat of two long hours. Happily death is almost instantaneous, for it is a literal crushing out of life.

Eight minutes have elapsed, and that spiral coil is still wound up, rigid and motionless as a rope of iron. How patient the creature is! So still, so quiet, one would hardly think it was alive. Now it withdraws its head from underneath the coils. This releases a part of the transverse fold, and gives to the head ten inches of free movement. That head is raised above its prey, and is there set at the extremity of an impending and motionless curve. Nor is there the least aspect of snakishness about the act, but a certain quiet air, as though the reptile was conscious that the thing was done. A change comes at last. The head is still aloft, the eyes are fixed on its victim, the neck and part of the long thorax swell with inspiration; then comes that indescribable blowing. It is evidently taking a good long breath after a tough job. There may be in it a relief to its nervous excitement. Is there in it any exultation? Who can tell? Now comes a slow, but general slackening, or relaxing of the coils. The head, however, is still kept aloft with the eyes set upon the little mangled body. As the upper coil opens the victim lies on one side, as if in a nest. The snake lowers its head and touches it with that delicate bifid tongue, which is doubtless an organ of acute feeling. Then it rubs its head against the dead little hero, pushing the head into, and moving it all round the coil for that purpose. This toying with its victim lasts about four minutes. At length the coils all slacken, and Pituophis stretches herself out for repose. She is now utterly indifferent about her conquest. We left the rat in the box until next day, when it was removed and subjected to a *post mortem*. I found the vertebræ dislocated in three places, one

place just back of the neck, and two places in the dorsal region.

Early in the second summer a splendid male Pituophis was sent me. It was seen swimming across a stream, and was captured after landing. It was about six feet in length. But a few minutes before an equally fine specimen was killed in the same place, and the belief was that this was its mate. The coloring was very bright, showy splashes of pale chestnut predominating. I put it with my female specimen. They took no notice of each other, though kept together until May of the next year, when the male died. I think it got some rough handling in its capture, from which it never recovered.

Old charcoal burners in the Pines entertain the belief that the pine snake destroys the rattlesnake; but I have never found the man that had seen the pine snake kill a rattlesnake. They say that generally they can tell if a rattlesnake is around by the smell, which is like that of a cucumber. That the pine snake can emit an odor of a far more powerful character than the rattlesnake, is well known to these men. Their notion is that the smell is thrown out with the breath when blowing. This I think is a mistake, except the fact that it may occur during the blowing, which is itself an act or manifestation of rage or other high emotion. There was a man in the Pines who kept up an objectionable familiarity with the snakes. He would put a black snake inside his hat, then go into the hostelry and banter some of the loungers to knock off his hat, an accommodation which was soon granted, when a display of Gorgon locks of raven hue would result, that constituted him, for the nonce, sole occupant of the premises. Such coolness would make any one a good observer. This man said he fell in with a very large pine snake in the woods. His words very nearly were, "You can tease a pine snake with a stick, and instead of trying to get away, it will coil itself, and give up. So I took a long stick and began teasing it. It reared itself, and began blowing (bellowing) fearfully, and there fell on me a stench so sickening, that I could not stand it. It seemed to rain on me! I turned and ran away as hard as I could! That the adult snake has this singular power must be accepted. The same experience has been given me by many others, and I have myself experienced it, though in a faint degree. I am not disposed to believe that it comes from the animal's mouth, however, and think that it can be

determined only by dissections of the posterior parts. This faculty may be compensatory — a means of defence for an animal naturally timid. And may it not be also for sexual attraction? In this particular it is probable the pine snake is not singular, and it is likely that where this function is feeble in the other snakes, it is strong enough for the latter purpose. A man very much beyond the average intelligence and education, a teacher in the Pines, said to me "I once saw a black snake come out of the woods into the soft sandy road; and it acted precisely as a dog does that is nosing out a scent. The snake came to a snake's track in the sand. It at once put itself in the track, and began to follow it; when, seeing me, it turned off to the woods and got away."

As is well known, the capacity of abstinence from food is remarkable among the serpents. Late in September, 1874, I killed a mouse, and gave to the female Pituophis. She seized it, gave it the usual squeeze, then swallowed it, taking just five minutes for the latter task. The next day I gave her another dead mouse, with exactly the same results. This was the first time that she had broken fast since September, 1873, — just one year before!

She had in the previous year on one occasion eaten a good-sized rat, that was given her dead, taking eighteen minutes for the operation. And I must mention here that I have known the Flat-head Adder or Blowing Viper, *Heterodon platyrhinos*, to eat the heads of the common eel, left on the shore by the fisherman. So that the assertion that snakes will not take food that they have not killed themselves, is not in all cases correct.

Late in August, 1873, I noticed that the snake seemed sickly. The dim, horny look of the eyes told the reason. She was nearly, if not quite, blind; and was about to cast off her old skin. To me, this was a time of anxiety, I was so anxious to witness an operation which I had never seen. On the 30th, owing to a restless night from illness, I rose later than usual. Went directly to the snake box — what a disappointment! The snake had cast her skin, and was now all aglow in her new winter dress. I was struck with the wonderful clearness of the eyes, and was reminded of the shoreman's slang, as previously given. I now saw a new significance in their vulgar speech; and it occurred to me that many a poor ophthalmic sufferer would rejoice if he could thus exuviate his optics.

But the desire came at last. Near the close of September, 1873, at 1 P.M., looking into the box, I saw that the snake had started the skin from her head. It was a little torn at the snout, and I found that the head and neck were denuded for about two inches. The denuding process was going on, but very slowly. Doubtless the chief difficulty was in starting the skin, and I felt sorry that I did not see the start. The neck was slowly becoming divested of the old cuticle, which, at first glance, had a sort of rolling aspect. What surprised me was the fact that there was not the least friction in the act; that is, there was no rubbing against any exterior object. As the old skin at this time is very moist and soft, any swelling of the body stretches and loosens it. So soon as the exuviation has reached the part of the body containing the larger ribs, this doffing of the old suit proceeds more rapidly, and with a singular system. It is done just in this way. Exactly at the place where the skin seems to be moving backward, a pair of ribs expands. This action enlarges the body and loosens the skin at that place. In this movement both ribs in the pair act at the same time, just as the two blades of the scissors open together. Now comes in a second movement of this pair of ribs. One of them — say the one on the right side — is pushed forward, and made to slip out of the constriction, when it is immediately drawn backward, that is, against the neck of the old skin. Now the left rib makes a like advance, and in a like manner presses backward. Thus the final action of the ribs is not synchronous, but alternate. And how notable becomes the sameness of result in this action with that of the alternate hitching of each side of the mouth when swallowing. Indeed, swallowing by a serpent is a misnomer; for that laborious hitching is not a pushing of the prey down the gullet, but a drawing of the body over it. The western man said, he always felt better after getting himself around a two-pound steak. With the serpent, this is a literal fact; it puts itself outside of its victim. And so with the singular action of the ribs — it seems to push the skin backwards; but this is an illusion, for it actually pushes itself forward, and advances out of the skin, thus with each movement or advance, lengthening the double cylinder behind; that is, the old hose evolves from itself forward, though it appears to be rolled on itself backward.

The ribs of a serpent, which extend very nearly throughout its whole length, are very much smaller in the neck and tail. At

these parts exuviation is much slower than when the larger ribs have play. This rib action produced a singular automatic movement of the serpent on the floor of its box, and even across the folds of its companion, which kept as still as if it were dead. The movement of the snake's body, as the skin did not follow it, gave the creature the appearance of crawling out of a tubular case. The skin of course was presented inside out, so that every scale showed its concave side, which was true also of the scales of the eyes. To all this was one exception. The last scale of the tail is a hollow pyramidal, or four-sided spike. It is fully half an inch in length. This, for plain reasons, was not inverted. The entire process of exuviation, allowing five minutes for the part that I did not witness, took thirty-five minutes.

There was a great contrast of color and brilliancy between the old and the new attire! Unversed in serpentine psychology, we are not able to say what went on in the caput of this creature, which the adage has made so famous for wisdom. With a dress of such a rich creamy glow, and such adornings of brown, and chocolate, and chestnut, what blame if it were proud of its new attire? She certainly seemed to show her feelings in a feline way, for she rubbed her head, with a seeming cat-like complacency, against that of her companion. As for him, poor fellow, he had been ten weeks trying to get his trousers off, and after this panting time, had only succeeded in tearing the garment. He seemed now to be acting like that human, who, after a vain tussle with his tight boots, retired to allow his mind time to regain its composure. The truth told, it took Mr. Pituophis exactly three months to get off his pantaloons. It would only come off in bits at a time, and by painful friction, which, as shown above, is not the normal way of a snake's undressing. Indeed, it looked as if a valet would have to be provided. But on the 13th of October, a warm Indian summer day, he was successful in doffing his old vestment. Having got out of those dilapidated tights, he looked more comfortable, and in his new suit appeared a very presentable fellow.

Even in its excrementing, it observes a singular method, which, however, is perhaps not peculiar to itself. In every instance — and I have made a number of observations — the first voiding is a clear liquid. This would make a circular spread on the floor of the box, about as large as one's hand. In the middle of this was immediately voided a heap of a uniform granular powder, of a

deep straw color. This was about as wide as a dollar. On top of this was a smaller mass composed entirely of hair, unchanged from its natural color. This was the indigested portion of its last meal. This excrement was made three weeks after its meal of two rats. It is to be remarked, there was not the smallest bit of indigested bone. I regret that my intention to secure chemical analyses was not carried out.

When the summer was advanced I put into the box a fresh sod of grass. After a while the snake became very fond of it, but its first acquaintance with it was the occasion of a singular demonstration. The stupid thing at once assumed an attitude of threatening inquiry. It raised its head aloft, and in the direction of the strange object, vibrating its tongue, and keeping its eyes intently fixed upon it. That head, and the part of the body thus elevated looked as rigid as if cast in brass. And for a full hour was that statuesque rigidity of posture sustained. How much longer I know not, as I was called away. This singular command of the muscles is probably peculiar to all the constrictors. The common black snake can be taken in the hand by the lower part of the body, and the rest of the animal be projected forward, of its own will, in a straight rigid line. Owing to this command of the muscles the pine snake is capable of performing some evolutions, which are not only beautiful, but so intricate and delicate as to make them seem imbued with the nature we call spiritual. I have often seen the Pituophis spread out in loose coils with its head in the central one, wake up after a long repose and begin a movement in every curve, the entire body engaged in the mazy movement, with no going out, or deviation from the complicated pattern marked on the floor. Observing this intricate harmoniousness of movement, I thought of the Seer's vision of the mystic wheels. Those revolving coils—"As for their appearances, they four had one likeness, as if a wheel had been in the midst of a wheel." In the popular pictorial tablets of Natural History in Japan, their generic idea of a snake is given in the words *Kuchi Nawa*, "Rope with mouth at end." And this is pretty much the crude popular conception of an ophidian the whole world over. But the movements of a serpent are never started rope-like at one end, and thus transmitted to the other ; nor is the movement like the force-waves sent through a ribbon vibrating in the air. The movement consists of numberless units of individual activities, all reg-

ulated by and under the perfect control of one will, that is felt in every curve and line. There is some likeness to the thousand personal activities of a regiment seen on their "winding way." And all this perfection of control of so many and complicated activities is true, whether a serpent like an ogre be crushing its victim's bones, or as a limbless posturist be going through its inimitable evolutions. In our thinking a serpent ranks as a paradox among animals. There is so much seeming contradiction. At one time encoiling its prey as in iron bands; again assuming the immovable posturing of a statue; then melting into movements so intricate and delicate that the lithe or limbless thing looks like gossamer incarnate. In this creature all the unities seem to be set aside. Such weakness, and such strength; such gentleness, and such vindictiveness; so much of beauty, and yet so repulsive; fascination and terror:—what need of wonder that whether snake or python, the serpent should so figure in the myths of all the ages, and the literature of the whole world! Yes, in the best, and the worst thinkings of men!

BOTANICAL OBSERVATIONS IN SOUTHERN UTAH, IN 1874. I.

BY DR. C. C. PARRY.

THE hastily gathered collection of plants made by Fremont on his adventurous return trip from California, in the spring of 1844, contained quite a number of remarkable new forms, from the little known district adjoining the valley of the Virgen, then included in the Mexican Territory of Upper California. Several of these newly discovered plants, as far as the imperfect material allowed, were described by Dr. Torrey and Prof. Gray, in Fremont's Report, "Plantæ Fremontianæ," and other scientific publications. Subsequently the inaccessibility of the country, and the hostile character of the Indian tribes occupying this district, prevented for a time farther botanical researches. With the growth of Mormon settlement gradually extending southward from Salt Lake, the obstacles to exploration were in great measure removed and the valley of the Virgen lay along the line of one of the travelled routes to southern California. During this period, late in the year

1855, a French naturalist, named J. Remy, passed over this route from Salt Lake to Los Angeles, and made a scanty collection of plants on the journey, which were afterwards deposited in the Paris Museum. His published narrative, entitled "Pays des Mormons," contained only very general allusions to the botany of the region traversed, and no scientific account was given of his collections, the material being apparently imperfect and fragmentary. Since then, up to the year 1870, we have no account of any botanical collector visiting this district. At the latter date (1870), at the suggestion of the writer, Dr. E. Palmer, then in the joint-service of the Department of Agriculture, in Washington, and the Smithsonian Institution, was induced to visit this section on a collecting tour, extending to the mouth of the Colorado and the Pacific coast. Leaving Salt Lake in the latter part of May, he spent about three weeks in the vicinity of St. George, collecting in that vicinity a number of new species of plants which were mainly described in Mr. Watson's Botanical Report of the geological exploration, 40° parallel, vol. v.

In the following years (1871-2), the expeditions of Lt. Wheeler and Major Powell, both touched on this district, and small collections of plants, made by Mrs. E. P. Thompson, Capt. Bishop and others connected with these surveys, added several new species to the flora of this district, being described by Mr. Watson in the AMERICAN NATURALIST (Vol. vii, pp. 299–303).

In addition to these published sources, several local collectors have at different times aided materially in extending our knowledge of the plants of this region, among whom may be mentioned as especially worthy of notice, Mr. A. L. Siler, and J. E. Johnson, Esq., both residents of southern Utah.

Being desirous of obtaining a more complete view of the botanical features of this district, and especially of securing the evanescent spring plants, which on account of the late season of gathering or hasty mode of travel, other collectors had mainly neglected, the writer undertook a botanical collecting tour, early in the present season (1874). It seemed like anything but a promising prospect for the success of this enterprise, to encounter on my arrival at Salt Lake, March 20th, a snowfall of nearly two feet, interfering seriously with the ordinary means of travel, and rendering the journey over the high intervening country, between Salt Lake and St. George, a distance of 350 miles, exceedingly tedious and disagreeable.

Not before passing over the rim of the great basin, within a short day's travel of my destination, was there any appearance of advancing vegetation; but on dropping down suddenly into the valley of the Virgen, on April 5th, the whole floral aspect assumed a change almost magical; orchards in full bloom including peach, almond, and apricot, marked at a distance by a perfect blaze of blossoms the scattered settlements, while the lucerne fields with their deep green foliage were nearly ready for a first forage crop.

Over the intervening desert table-land the aspects of advanced spring were evidenced in rainbow-colored patches of *Phacelia Fremontii* Torr. and bright yellow clusters of *Eunanus Bigelovii* Gray (No. 147). The approach to St. George, which I had previously selected as the central point of my explorations, was at this season, and under the circumstances of the case in contrast with the bleak country just passed over, peculiarly attractive. The variety of rock exposure in the form of steep mural cliffs of red sandstone, and high basaltic *mesas*, with their slopes of broken *talus*, gave promise of a rich harvest, which the result of my labors fully realized.

From the 5th of April up to June 1st, there was a continuous succession of interesting forms, almost bewildering in their singular botanical features. Early in the season, the chief attraction centred on the evanescent annuals, which were scattered in great profusion over every bare knoll, in rock crevices, or under the scant shelter of the dull colored desert shrubbery. Largely represented among these is the genus Phacelia, including *P. Fremontii* Torr. (No 177), whose showy spikes continue to unfold a succession of blossoms for four weeks or more. Hardly less showy is the *Phacelia crassifolia* Torr. (No. 182), with flowers of an intense blue shade, thickly scattered over gypseous clay knolls. This latter species frequently becomes dwarfed in exposed places, and spreads out in the form of purple patches over the bare soil.

In rock crevices we find the delicate *P. micrantha* (No. 181) associated with *P. rotundifolia* (No. 183), while later in the season, *P. crenulata* Torr. (No. 180), *P. curvipes* n. sp.? (No. 179), and the biennial *P. Palmeri* Torr. (No. 176), keep up the series. Hardly inferior to the above noted omnipresent forms of early spring vegetation, must be reckoned the different species of Gilia, which, though generally less showy, vie with them in variety and abundance. These latter include, besides the widely distributed and very variable *Gilia inconspicua* Dougl. (No. 199), the rarer

forms of *G. leptomeria* Gray (No. 197), *G. demissa* Gray (No. 196), *G. Bigelovii* Gray (No. 189), *G. flocosa* Gray (No. 192), *G. polycladon* Torr. (No. 191), *G. setosissima* Gray (No. 190), and a very delicate species with light yellow flowers, looking like flax, *G. filiformis* n. sp. (No. 187).

Among other interesting dwarf forms characterizing the early spring flora, may be noted *Thysanocarpus curvipes* Hook., *Malvastrum exile* Gray, *Lupinus Sileri* Watson, *Actinolepis Wallacei* Gray, *Actinolepis lanosa* Gray, *Syntrichopappus Fremontii* Gray, *Layia glandulosa* H. & A., *Styloclyne micropoides* Gray, *Nemacladus ramosissimus* Nutt., *Nama demissa* Gray, *Pterostegia drymarioides* F. & M.

Somewhat later in the season, as we shall have occasion to note farther on, a different class of annuals, largely represented by Eriogoneæ and Boragineæ, come forward to continue the series of evanescent forms.

Of perennial plants the early spring gave abundant promise, in the opening leaf and developing bud, of many strange forms. Among these the first to attract attention is a very common bushy shrub, with small inconspicuous flowers, crowded along the slender branches, almost hidden from view in the densely fasciculate leaves. This, which is readily recognized in its habit and peculiar peach-leaf odor, as belonging to the *Amygdaleæ* group of *Rosaceæ*, was characterized by Dr. Torrey in "Plantæ Fremontianæ" (fig. 10), from imperfect material under the name of *Emplectocladus fasciculatus* Torr. The more complete material now collected shows it to be not generically distinct from Prunus, being indeed closely allied to the *Prunus minutiflora* Engel.; it has accordingly been reduced by Prof. Gray to a section of *Prunus*, viz.: *P.* (*Emplectocladus*) *fasciculata* Gray (No. 56). By the inhabitants of the country it is known under the appropriate name of "*wild almond*," its small fruit, though bitter, being occasionally eaten. Among other early flowering shrubs of this district, may be enumerated *Rhus aromatica* Ait., and one of the numerous forms of the variable *Amelanchier Canadensis* T. & G. Quite commonly met with in deep sandstone ravines and on rocky slopes is the singular one-leaved ash, *Fraxinus anomala* Torr. (No. 210). This forms a clumpy bush eight to twelve feet in height, with bright green foliage, set off later in the season by pendent fascicles of fruit, of which the separate seeds are not unfrequently

3-angled. From the mature seed somewhat copiously collected, it is to be hoped that this singular species may be introduced into our gardens.

Of early bulbous plants *Androstephium breviflorum* Watson (No. 223) is quite common on all gravelly hills, succeeded somewhat later in the season by *Milla capitata* (No. 256), which latter exhibits an equally well-marked corona subtending the stamens, thus apparently invalidating the distinctions which have been relied on for separating the allied genera of *Milleæ*.

Early in May, *Culochortus flexuosus* Watson (No. 254) is conspicuous on hill-sides, with its showy tulip-like blossoms, which, on account of its prolonged branching flower stem, continues to flower for a longer period than most species of this attractive genus. The general Indian name of "*Sego*" is applied indiscriminately to all the edible bulbs of this region. Apparently quite out of place in this arid climate, we notice quite frequently on the perpendicular face of moist sandstone rocks, *Adiantum*, *Capillus venesis* L. (No. 262). Still more interesting is a common fern growing in dry rock crevices, resembling *Cheilanthes*, which Prof. Eaton on a critical examination determines to be a new species of *Notholæna* characterized by him as *N. Parryi* n. sp. (See appendix No. 263).

With the disappearance of late spring frosts, which frequently continue to the latter part of April, and occasionally as late as early May, the intense heat of the lengthening days, rarely obscured by clouds, or tempered by showers, brings forward a rapid development of the more characteristic forms of vegetation. By May 1st orchards had mostly dropped their blossoms; the fruit of the apricot and almond were developing, and strawberries beginning to ripen, giving to fields and gardens a summer aspect. In the open country an analogous feature is brought to view in the native vegetation. We accordingly note the appearance of several species of Œnothera, conspicuous among which is a large yellow-flowered one, which being undescribed, I take pleasure in dedicating to my esteemed friend, J. E. Johnson, Esq., as *Œnothera Johnsonii* n. sp. (See appendix No. 64). Mr. Johnson, who has had this plant for many years in his garden, called my attention to the regularity and suddenness of its opening, from fifteen to twenty minutes after sunset. This opening process, as frequently observed by both of us, is accomplished by a shrinking

downward of the valvular calyx, the accumulated tension at a certain point suddenly releasing the segments from below upwards, which, becoming reflexed, allows the closely-confined convolute corolla to unfold visibly, its petals expanding in about thirty seconds, to a horizontal position. Quite constantly, just at this time, a small bee, apparently on the watch, darts in and loads itself with the stringy, adhesive pollen, to be carried, probably, to another flower. Generally, soon after, another bee on the same quest lands on the same flower, and finding the pollen gone, travels quickly over the stigmatic arms and soon flies away. This process frequently repeated ensures cross-fertilization.

Other *Œnotheræ* include a large white-flowered variety of the polymorphous *Œ. albicaulis* (No. 63); as a rarity we also meet with the very neat *Œ. primiveris* Gray (No. 65).

Of the group belonging to the *Chylisma* section, we have three well-marked forms represented. Of these, Nos. 73–74 are referred by Mr. Watson to *Œnothera brevipes* Gray; both have yellow flowers, of which those of No. 73 are most conspicuous. No. 74 is distinguished by a more branching habit, smaller light-yellow flowers, longer pedicels, and more conspicuous pinnatisect radical leaves. A third species of this section is characterized by Mr. Watson as *Œnothera Parryi* n. sp. (See appendix No. 72). This latter is of a singularly graceful habit, generally much branched, its prolonged spike of small yellow flowers being succeeded by distinctly clavate capsules, curving upwards from a slender divaricate pedicel. Quite constantly associated with this latter species, occupying dry gypseous clay knolls, is a very neat and showy *Mentzelia* (No. 78). This, though closely allied to the common *M. multiflora* Nutt., seems to present characters sufficient to distinguish it as a new species. Observing the two growing often side by side, the differences in habit, time of flowering and floral characters seem sufficiently distinct, nor were there any intermediate forms noticed. In the meantime it may be well to wait for a more full revision of this genus before venturing to add to the number of doubtful species.

Common at this season upon all sandstone or gravelly knolls, is the charming *Dalea Johnsoni* Watson (No. 40), with its deep indigo blue spikes. Now also comes forward *Coleogyne ramosissima* Torr. (No. 57), its dull green foliage being relieved by a profusion of light-yellow blossoms. *Aster tortifolius* Gray (No. 91),

with its large pale-blue heads, adds an unwonted brilliancy to the clefts of dark basaltic rocks. *Audibertia incana* Benth. (No. 159) is conspicuous along the line of dry ravines, with its dense blue spikes, and silvery foliage, exhaling a most pungent perfume. Other varieties include *Lepidium Fremontii* Watson, *Hymenoclea salsola* T. & G., *Franseria dumosa* Gray, *Salazaria Mexicana* Torr., *Lycium Torreyi* Gray.

Not least among the attractions of this flowering season are the Cacti, which include *Opuntia rutilla* Nutt., presenting a perfect mass of delicate pink rosettes, set in a bed of spines. *Cereus Engelmanni* Parry exhibits flowers of a deeper purple shade, which are succeeded by a delicious fruit, when it can be safely extracted from its thorny envelope. *Mammillaria phelosperma* Engel., or "the fish-hook cactus," is found as a rarity in rocky clefts, at this season adorned with its bright red fruit. On all gravelly knolls in this section a common arborescent *Opuntia* is met with (*O. Echinocarpa* Engel.). This species has an inconspicuous yellowish green flower nearly buried in a mass of barbed spines; otherwise its usually repulsive features are partly utilized by birds, who find in their spiny recesses, nesting places secure from the attack of snakes.

Chenopodiaceæ are everywhere largely represented by the following, viz., *Atriplex expansa* Watson, *A. confertifolia* Watson, *A. Nuttallii* Watson, *A. canescens* Watson, *Kochia Americana* Watson, *Suæda diffusa* Watson, *Eurotia lanata* Moquin, and *Grayia polygalvides* H. & A., the latter with much more graceful foliage than noticed farther north, almost reconciles one to the imposition of this honored botanical name to a "grease wood."

The undergrowth comprises quite a number of singular *Cichoraceous Compositeæ*, including *Malacothrix Coulteri* Gray, *M. Torreyi* Gray, *Rafinesquia Neo-Mexicana* Gray, *Calycoseris Wrightii* Gray, *Microseris macrochæta* Gray, *M. linearifolia* Gray, *Stephanomeria Thurberi* Gray, *S. exigua* Nutt., *Lygodesmia exigua* Gray. To these must be added as especially worthy of notice, the charming *Glyptopleura setulosa* Gray (No. 129), with its pure white blossoms, and cut fringed leaves, pressed close to the ground. This growing abundantly everywhere on gravelly soil, or dry bottom land, presents a succession of flowers opening in bright sunshine. Not unfrequently on gravelly slopes we meet with the rare *Compositeæ*, *Monoptilon bellidiformis* Gray (No. 100), heretofore only known

from a single Fremontian specimen. The large class of annual and perennial *Eriogoneæ* come forward in the latter part of May, allusion to which must be deferred to a succeeding paper, together with some more detailed notices of excursions to the higher mountains and alpine districts, south and west of St. George.

NOTE. The numbers affixed to species in the foregoing paper, correspond to the numbered sets, in the distributed collection.

THE COLOSSAL CEPHALOPODS OF THE NORTH ATLANTIC.

BY PROF. A. E. VERRILL.

IN a former article published in the NATURALIST (vol. viii, p. 167, March, 1874) the writer gave a brief account of several gigantic cuttle-fishes, or "squids," which have been observed or captured at or near Newfoundland,[1] and in an earlier volume (vii, p. 91) Dr. Packard gave an account of previous captures of similar huge Cephalopods on the coasts of North America and Europe. The existence of several distinct species of these colossal ten-armed Cephalopods has been satisfactorily demonstrated in the various papers that have been written upon the subject both in Europe and America. Most of the specimens hitherto obtained have been taken in the Atlantic Ocean, but at least one gigantic species (*Enoploteuthis unguiculata*) inhabits the Indian Ocean, while the origin of some of the described specimens is not known.

In this article I propose to describe portions of five different specimens of these monsters, now in my possession, and also to give some account of five other specimens that have been observed on our side of the Atlantic.

The five specimens that I have been able to study evidently belong to two quite distinct species, both of which belong to the genus *Architeuthis* of Steenstrup (or *Megaloteuthis* of Kent). The largest of these is represented only by the jaws of two

[1] See also an article on this subject by the writer, in the "American Journal of Science," vol. vii, p. 158, Feb., 1874; and letters from Mr. Alexander Murray in the NATURALIST, vol. 8, p. 120, Feb., 1874.

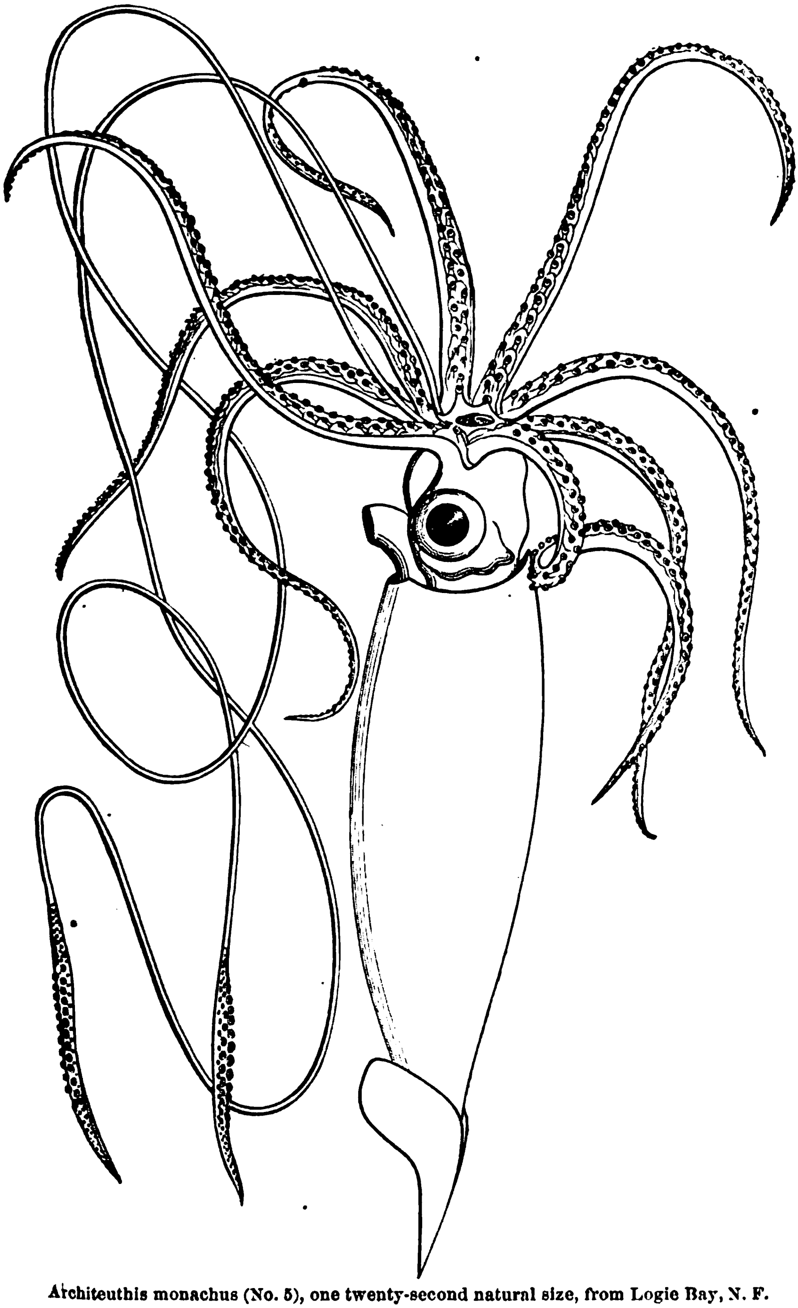
specimens, one of which (No. 1 in my former articles) was found floating at the Banks of Newfoundland, and the other (which we will designate as No. 10) was taken from the stomach of a sperm whale. The upper jaw of the latter was imperfectly figured by Dr. Packard in his article referred to above, and it is the largest jaw yet known. These belong to an apparently undescribed species, which I propose to name *Architeuthis princeps*,[2] and shall describe more fully farther on. It is readily distinguished from the following by the blacker, thicker, stronger and more incurved beaks, and especially by the large and very prominent tooth or projection, arising from the margin of the cutting edges of the alæ, on the lower jaw. The body appears to have been relatively much longer than in the following species.

The second species, which I consider identical with the *Architeuthis monachus* of Steenstrup, is more fully represented by parts of three individuals, and seems to be the species most commonly met with on the coasts of Newfoundland and Labrador.

The most complete specimen (fig. 1) that has ever come under scientific observation was captured in November, 1873, at Logie Bay, near St. John's, Newfoundland. It became entangled in herring-nets and was secured by the fishermen with some difficulty and only after quite a struggle, during which its head was badly mutilated and severed from the body, and the eyes, most of the siphon-tube, and the front edge of the mantle were destroyed. Fortunately this specimen was secured by the Rev. M. Harvey of St. John's. After it had been photographed and measured, he attempted to preserve it entire in brine, but this was found to be ineffectual, and after decomposition had begun to destroy some of the most perishable parts, he took it from the brine and, dividing it into several portions, preserved such parts as were still undecomposed in strong alcohol. These various portions are now in my possession, and with the photographs have enabled me to present a restoration, believed to be quite accurate, of the entire creature (fig. 1). In this figure the eyes, ears, siphon-tube, and front edge of the mantle have been restored from a small squid (*Loligo pallida*) to which this gigantic species seems to be nearly

[2] This species was named and characterized in a communication made to the Connecticut Academy of Sciences, Nov. 18, 1874, and will be desciibed in greater detail in its Transactions.

Fig. 1.



Architeuthis monachus (No. 5), one twenty-second natural size, from Logie Bay, N. F.

allied in many respects.' The other parts have been drawn directly from the photographs and specimens.[3]

Mr. Harvey has published popular accounts of this specimen and the previously captured arm of a still larger one, in an interesting article in the Maritime Monthly Magazine of St. John, N. B., for March, 1874, and in several newspapers.[4] These articles, and extracts from them, have been widely copied in the newspapers and magazines. To him we are, therefore, mainly indebted for these latest and most important additions to our knowledge of these remarkable animals. The preserved parts of this specimen (No. 5) which I have been able to examine are as follows: the anterior part of the head, with the bases of the arms, the beak, lingual ribbon, etc.; the eight shorter arms, but without the suckers, which dropped off in the brine, and are now represented only by the strong marginal rings; the two long tentacular arms, which are well preserved, with all the suckers in place; the tail; portions of the "pen" or internal shell; the ink-bag and pieces of the body.

Since this is the most complete specimen hitherto obtained, it will be first described as a standard for comparison with the other less complete ones.

The general appearance and form of this species,[5] which appears

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[3] The figure was originally made from the photographs only, by Mr. P. Roetter, of the Museum of Comparative Zoology, but after the arrival of the specimens it had to be altered in many parts. These necessary changes were made by the writer, after a careful study of the parts preserved, in comparison with the photographs and original measurements.

[4] Acknowledgments are also due to Mr. Alexander Murray, Provincial Geologist, who coöperated with Mr. Harvey in the examination and preservation of these specimens, and who has also written some of the accounts of them that have been published. See the AMERICAN NATURALIST, vol. viii, p. 122, February, 1874; "American Journal of Science," vol. vii, p. 160; and "Nature," vol. ix, p. 322, February 26, 1874.

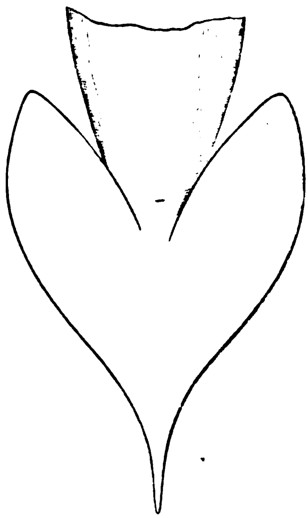
[5] Mr. W. Saville Kent, from the descriptions and photographs of this species, has seen fit to give it new generic and specific names, viz.: *Megaloteuthis Harveyi*, according to notices of his communication made to the Zoological Society of London, March 3, 1874, in "Nature" (vol. ix, p. 375, March 12, and p. 403, March 19). But as no sufficient reason was given for doing so, in the notices referred to, and as his original communication appears not to have been published yet (at least it has not been received here) I am unable to judge what his actual reasons for this proceeding may be.

My identification is based on a comparison of the jaws with the jaws of *A. monachus*, well figured and described by Steenstrup. Their agreement is very close in nearly all respects, but the beak of the lower jaw is a little more divergent in Steenstrup's figure. His specimen was a little larger than the one here described and was taken from a specimen cast ashore in 1853. So that Mr. Kent was probably unaware of that specimen when he said ("Nature," ix, p. 403) that *A. monachus* "was instituted for the reception of two gigantic Cephalopods, cast on the shores of Jutland in the years 1639 and 1790, and of which popular record alone remains."

His statement that *Architeuthis dux* Steenstrup is known from the beak alone is

to be the *Architeuthis monachus* of Steenstrup, is well shown by fig. 1. From the great size of the large suckers on the long arms, I judge it to be a male. The body was relatively stout, and according to the statement of Mr. Harvey, it was, when fresh, about seven feet long and five and one-half feet in circumference. The portion of the body shown in the photograph appears to have been only about five and one-half feet long, and is badly mutilated anteriorly, so that it is possible that Mr. Harvey has allowed too much for the missing parts. In restoring the figure here presented, the length of the body was reckoned at seven feet, and reduced twenty-two times. The "tail" or caudal fin (fig. 2) is said by Mr. Harvey to have been twenty-two inches across, but the preserved specimen is considerably smaller, owing, undoubtedly, to shrinkage in the brine and alcohol. It is remarkable for its peculiar spear-shaped or broad sagitate form. The posterior termination is unusually acute and the lateral lobes extend forward considerably beyond their insertion. In the preserved specimen the total length, from the anterior end of the lateral lobes to the tip of the tail, is twenty-three inches; from the lateral insertions to the tip nineteen inches; from the dorsal insertion thirteen and five-tenths inches; total breadth about fifteen inches; width of lateral lobes six inches. The body, as seen in the photograph, is badly collapsed and it must be a matter of great difficulty to obtain the true diameter of the body in any of these large squids, owing to the

Fig. 2.



Tail of No. 5, one-tenth nat. size.

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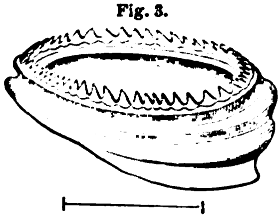
erroneous, for Steenstrup, Harting, and Dr. Packard, in their articles on this subject, all state that the suckers, parts of the arms, and the internal shell or pen were preserved, and they have been figured by Prof. Steenstrup; Harting has also given a figure of the lower jaw. Steenstrup mentions having the arm-hooks (Tandvæbningen), which would indicate a genus distinct from our species.

Should the *Architeuthis dux* prove to belong to a genus distinct from this and all known genera, it might perhaps be taken as the type of *Architeuthis*, and in that case the generic name given by Kent could be retained, and the two species here described would then be called *Megaloteuthis monachus* and *M. princeps*, if my identification of the former species be correct.

fact that they collapse greatly when taken from the water. The circumference of the body given above may, therefore, be considerably too small. In that case the figure represents the body more slender than it should be. The head was probably at least equal to one-fifth the length of the body. The eight shorter arms, when fresh, were, according to Mr. Harvey's measurements, six feet long and all of equal length, but those of the different pairs were respectively ten, nine, eight and seven inches in circumference. In alcohol they have shrunk considerably, both in length and diameter. They are three-cornered or triquetral in form and taper very gradually to slender acute tips. Their inner faces are occupied by two alternating rows of large obliquely campanulate suckers, with contracted apertures surrounded by broad, oblique, marginal rings, armed with strong, acute teeth around their entire circumference, but largest and most oblique on the outside (fig. 3). These suckers gradually diminish in size to the tips of the arms, where they become very small, but are all similar in form and structure. The largest of these suckers are said by Mr. Harvey to have been about an inch in diameter, when fresh. The largest of their marginal rings in my possession are ·65 of an inch in diameter, at the serrated edge, and ·75 beneath. The rings of the smaller suckers are more oblique and more contracted at the aperture, with the teeth more inclined inward, those on the outside margin being largest. The two long tentacular arms are remarkable for their slenderness and great length when compared with the length of the body. Mr. Harvey states that they were each 24 feet long and 2·75 inches in circumference when fresh. In the brine and alcohol they have shrunk greatly, and now measure only 13·5 feet in length, while the circumference of the slender portion varies from 2·25 to 3·25 inches. These arms were evidently highly contractile, like those of many small species, and consequently the length and diameter would vary greatly according to the state of contraction or relaxation. The length given (24 feet) probably represents the extreme length in an extended or flaccid condition, such as usually occurs in these animals soon after death. The slender portion is three-cornered or trique-

Fig. 3.



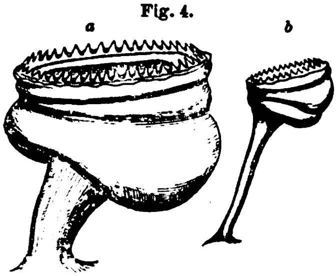
Ring of sucker from short arms of No. 5.

tral in form, with the outer angle round, the sides slightly concave, the marginal angles prominent, and the inner face a little convex and generally smooth, except toward the end, where it begins to enlarge. Although so slender, these arms are very strong and elastic. The terminal portion, bearing the suckers, is 30 inches in length and expands gradually to the middle, where it is 4·5 to 5 inches in circumference (6 inches when fresh), and 1·5 to 1·6 across the inner face. The sucker-bearing portion may be divided into three parts. The first region occupies about 7 inches, in which the arm is triquetral, with margined lateral angles, and gradually increases up to the maximum size, the inner face being convex and bearing about forty irregularly scattered, small, flattened, saucer-shaped suckers, attached by very short pedicels, and so placed in depressions as to rise but little above the general surface. These suckers have narrow marginal rings, with the thin edges nearly smooth, or minutely denticulate, and ·10 to ·12 of an inch in diameter, surrounded by a thick and prominent marginal membrane. These suckers are at first distantly scattered, but become more crowded as the arm increases in breadth, until they form five or six very irregular rows, covering the whole width of the inner face, which becomes here 1·6 inches broad. Scattered among these suckers are about as many low, broad, conical, smooth, callous verrucæ, or wart-like prominences, rising above the general surface, their central elevation corresponding in form and size to the apertures of the adjacent suckers. These, without doubt, are intended to furnish secure points of adhesion for the corresponding suckers of the opposite arm, so that, as in some other genera, these two arms can be fastened together at this wrist-like portion, and thus they can be used unitedly. By this means they must become far more efficient organs for capturing their prey than if used separately. Between these smooth suckers and the rows of large ones there is a cluster of about a dozen small suckers, with serrate margins, mostly less than a quarter of an inch in diameter, attached by slender pedicels, and with an oblique marginal ring, strongly and sharply serrate on the outer margin.

The second division of the sucker-bearing part of the arm succeeds the small suckers. Here the arm is well rounded on the back and flattened on the face, where it bears two alternating rows of very large serrate suckers, and an outer row of small ones on each side, alternating with the large ones. The inner edge is bor-

dered by a rather broad, regularly scalloped, marginal membrane, the scallops corresponding to the large suckers. On the other edge there is a narrower and thinner membrane, which runs all the way to the tip of the arm, just outside the suckers. In one of the rows of large suckers there are eleven, and in the other ten, above half an inch in diameter, but each row has at either end one or two smaller ones, from a half an inch to a quarter of an inch in diameter, so that either twelve or thirteen might be counted as belonging to the rows of large suckers. The largest of these (fig. 4, *a*) are from 1 to 1·15 inches in diameter at the margin. These are attached by strong, though slender, pedicels, so that their margins are elevated about an inch above the surface of the arm. Each one is situated in the centre of a pentagonal depressed area, about an inch across, bounded by ridges, which alternate regularly, and interlock on the two sides, so as to form a zigzag line along the middle of the arm. These large suckers are campanulate, and somewhat oblique; the marginal ring is strong, and sharply serrate all around. The small marginal suckers (fig. 4, *b*) are similar in structure, but more oblique, and mostly only ·3 to ·4 of an inch in diameter; they are attached by much longer and more slender pedicels, and their marginal teeth are relatively larger and more incurved, especially on the outer margin. By reason of their longer pedicels they rise to the same height as the large ones. The third, or terminal division of the arm, gradually becomes much compressed laterally, and tapers regularly to the tip, which is flat, blunt, and slightly incurved. Just beyond the large suckers, where this region begins, the circumference is 3·5 inches. The face is narrow and bears a large number of small serrate and pedicellate suckers, arranged in four regular alternating rows, and gradually diminishing in size to the tip of the arm, where the rows expand into a small cluster. These suckers are much like the marginal ones of the previous division, and at first are about ·25 of an inch in diameter, but decrease to about ·10 of an inch near the tip of the arm. The lateral membrane or fold of skin, of the preceding divisions, recedes farther

Fig. 4.

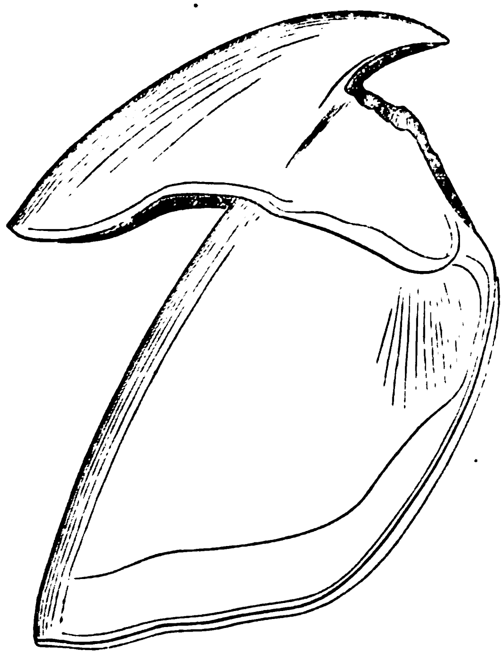


Suckers from long arms of No. 5. Natural size.

from the margin near the commencement of this division, and gradually passes around to the back side, where it forms a broad, thick wing or keel, extending to the tip. The color, where preserved, is pale reddish, with thickly scattered small spots of brownish red.

The form of the jaws of this specimen is well shown by figs. 5 and 6. When in place, these jaws constitute a powerful beak, looking something like that of a parrot or hawk, except that the

Fig. 5.

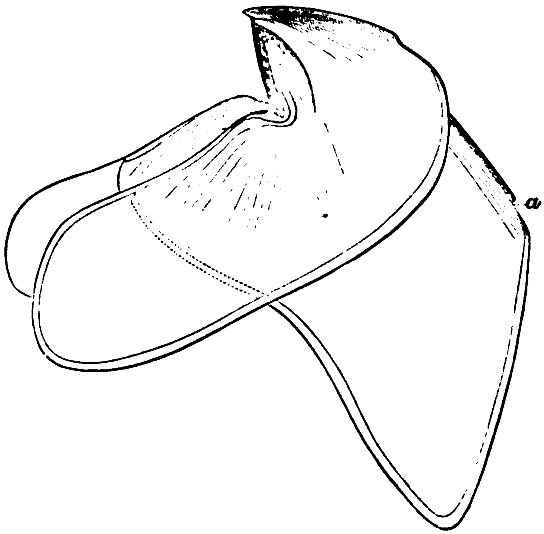


Upper jaw of Architeuthis monachus, No. 5. Natural size.

upper jaw shuts into the lower, instead of the reverse, as in birds. In life the great spaces behind and between the large, thin, lateral and posterior processes and expansions are filled with firm muscles and cartilage, which support and give great strength to the beak. The color is dark brown, becoming almost black toward the tip, where its substance is thicker and firmer, and smoothly polished externally. The upper jaw (fig. 5) measures 3·85 inches in total length; 1 inch in greatest breadth; and 2·50 from front to back.

The lower jaw (fig. 6) is 3 inches long; 2·75 broad; and 2·65 from front to back.

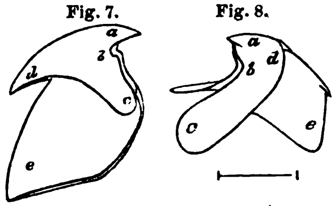
Fig. 6.



Lower jaw of Architeuthis monachus, No. 5. Natural size.

The small squids of our coast have a very similar pair of jaws. Those of *Loligo pallida* (figs. 7, 8), are here figured, twice the natural size, for comparison and to explain the terms used in describing the large jaws. The lower jaws of the large squids are more characteristic than the upper ones. In the one under consideration the points to be particularly noticed are, first, the narrow, but decided notch at the base of the nearly straight cutting edge; second, the broad, low, rounded projection or tooth on the anterior edge of the alæ; third, the angle between the edges of the alæ and the rostrum is nearly a right angle, and the tip of the jaw is slightly incurved.

Fig. 7. Fig. 8.



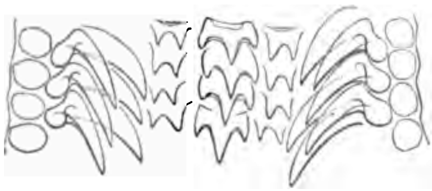
Jaws of Loligo pallida.[6]

[6] Figure 7, upper jaw, and 8, lower jaw of *Loligo pallida* V., enlarged two diameters; *a*, the rostrum or beak; *a b*, the cutting edge, with a notch at *b*; *b c*, the anterior edge of the alæ or wings; *d*, the frontal lamina in the upper jaw, or chin-portion (*mentum*) in the lower jaw; *e*, the palatine lamina in the upper jaw, or gular lamina in the lower jaw.

The most remarkable anatomical character observed in this specimen is found in the form and arrangement of the teeth on the "lingual ribbon," or *odontophore*, for in this respect it differs widely from all other known Cephalopods.

The ordinary squids and cuttle-fishes all have these teeth arranged in seven regular longitudinal rows; those of the three middle rows being generally two or three-pronged, as in *Loligo*

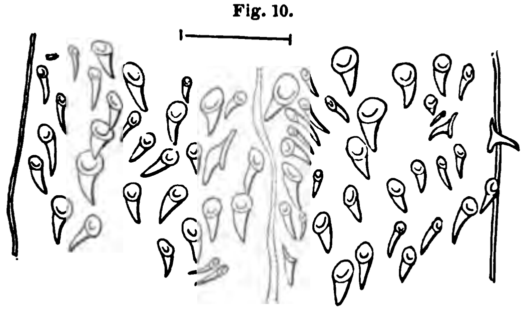
Fig. 9.



Teeth of Loligo pallida, much enlarged.

pallida (fig. 9), while the lateral rows have long, simple, fang-like teeth. But in this species (fig. 10), the teeth are very irregularly scattered over the surface of the broad thin membrane, and it is difficult to trace the rows, if such they can be called, for the arrangement seems to be somewhat in irregular quincunx. The number of rows, however, cannot be less than twenty. These

Fig. 10.



Lingual teeth of Architeuthis monachus, No. 5.

teeth are all simple, but vary considerably in size and form. They are all attached by a more or less rounded, flattened base, and all are considerably curved; some are broad and tapering; others are slender and acute; but the different forms and sizes are irregularly intermingled across the whole breadth of the membrane.[7]

[7] Irregular granules of silica are scattered in great numbers over the membrane among the teeth, and similar grains are embedded in the membrane lining the mouth.

This peculiar type of dentition must be regarded as an extremely generalized one. Whether it be also an embryonic type, or one that prevailed in ancient geological periods must be left for future determination. The character of these teeth indicates that this genus should hold low rank among the related genera. This conclusion is confirmed both by the structure of the caudal-fin, or tail, which somewhat resembles the early condition of the fins in the young *Loligo*, soon after it hatches, and by the form and structure of the internal shell or "pen," which is also very simple in structure, and but little differentiated or specialized.

The portions of the pen in my possession belong mostly to the two ends, with fragments from the middle region, so that although neither the actual length nor the greatest breadth can be given, we can yet judge very well what its general form and character must have been. It was a broad and extremely thin structure, of a yellowish brown color, and translucent. Its anterior portion resembles that of *Loligo*, but its posterior termination is entirely different, for instead of having a regular lanceolate form, tapering to a point at the posterior end, as in *Loligo*, it expands and thins out toward the posterior end, which is very broadly rounded or irregularly truncate, fading out insensibly both at the edges and end into soft membrane. The anterior end, for about an inch and a half, was rapidly narrowed to a pen-like point, as in *Loligo;* from this portion backward the width gradually increases from 1·2 inches to 5 inches, at a point 25 inches from the end, where our specimen is broken off; at this place the marginal strips are wanting, but the width is 5 inches between the lateral midribs, which were, perhaps, half an inch from the margin. Along the centre of the shell, there is a strong, raised, rounded midrib, which fades out a short distance from the posterior end, but is very conspicuous in the middle and anterior sections. On each side of the midrib is a lateral rib of smaller size. These at first diverge rapidly from the central one, and then run along nearly parallel with the outer margin and about ·4 of an inch from it, but beyond 11 inches from the point the margins are torn off. Like the midrib the lateral ribs gradually fade out before reaching the posterior end; near the place where they finally disappear, they are about 6 inches apart.

From the above description it will be seen that the most important and most characteristic features of this species, or rather of

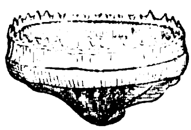
the *genus* to which it belongs, are to be found in the *lingual dentition*, in the *internal shell*, in the *form of the caudal-fins*, and in the cluster of small suckers and tubercles on the long arms. As already stated, the first three of these peculiarities indicate a low, or generalized structure, and therefore a low rank in our system of classification, unless it should be found to have some other characters not yet known and of greater importance, which might outweigh those here given. It will appear, therefore, that this genus of huge squids should be classed below *Loligo*, which, in its turn, would go below *Ommastrephes*, to which genus the common small squids of our northern coasts belong, for the latter genus has distinct eyelids, which are not found in *Loligo*, and the internal shell is also more specialized.

The pen of our *Architeuthis* seems to resemble that of the ancient genus *Teudopsis*, found fossil in the Jurassic formations, and contemporaneous with the huge marine saurians, *Icthyosaurus*, *Plesiosaurus*, etc., the "sea-serpents" of those ancient seas. May there not also be huge marine saurians still living in the North Atlantic, in company with the giant squids, but not yet known to naturalists?

Such a belief seems quite reasonable when we consider how many species of great marine animals, both among Cephalopods and Cetaceans, are still known only from single specimens, or even mere fragments, generally obtained only by chance. The specimen above described, is, however, not the only specimen of its kind that has been observed on the American coast.

I have received through Professor Baird, of the Smithsonian Institution, a pair of jaws and two large suckers of the long arms, which were taken from a specimen (No. 4), cast ashore in Bonavista Bay, Newfoundland. These jaws agree precisely in form and size with those described above, so that the size of these two individuals must have been about the same. The suckers (fig. 11), had been dried, and have lost their true form, but the marginal rings are perfect, and only ·92 of an inch in diameter, and though somewhat smaller than in the specimen just described, they have the same kind of denticulation around the margin. Their smaller size may indicate that the specimen was a female, but they may not have been the largest of those on the arm.

Fig. 11.



Sucker of long arm of Architeuthis monachus, No. 4. Natural size.

Accounts of an attack made upon two men by another specimen, in Conception Bay, Oct. 27, 1873, have been published in the NATURALIST,[8] and in many other magazines, as well as in the newspapers. In the encounter the monster lost two of his arms by amputation with a hatchet. A portion of one of these arms, measuring nineteen feet in length, was preserved by Rev. M. Harvey and Mr. Alexander Murray for the museum at St. John's, Newfoundland. It has been photographed, and cuts copied from the photograph have been published in some of the English magazines.[9]

It is stated that six feet of this arm had been destroyed before it was preserved, and the captors estimated that they left from 6 to 10 feet attached to the creature, which would make the total length between 31 and 35 feet. According to Mr. Murray the portion preserved measured but 17 feet in length, when he examined it, Oct. 31, 1873, after it had been a few days in strong brine; the circumference of the slender portion was 3·5 to 4 inches; of the enlarged sucker-bearing part, 6 inches; length of the part bearing suckers, 30 inches; diameter of largest suckers, 1·25 inches. Calculating from the photograph, the portion bearing the larger suckers was about 18 inches in length, and about 2·4 inches broad, across the face; distance between attachments of large suckers, 1·68; outside diameter of larger suckers, 1·16 to 1·28; inside diameter, ·74 to 1 inch; diameter of small suckers of the outside rows, ·40 to ·48 of an inch. Comparing all these dimensions with those of the Logie Bay specimen, and calculating the proportions as nearly as possible, it follows that this specimen was very nearly one-third larger than the latter, but the large suckers appear to have been relatively smaller, for they were hardly one-twelfth larger than in the Logie Bay specimen. As the relative size of the large suckers is a good sexual character among squids, it is probable that this individual was a *female*. In form, proportions and structure, it agrees very closely with the specimen first described, and therefore I do not hesitate to refer it to the same species. The lack of denticles on the margins of the large suckers is probably due to accidental injury, either before or

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8 Vol. viii, No. 2, p. 120, February, 1874, in a letter from Mr. Alexander Murray.

9 See "Annals and Magazine of Natural History," vol. xiii, p. 68; and "The Field," Dec. 13, 1873. The central line of this photograph is reduced four and a quarter times, while the front part is reduced about four times.

after death,[10] but this may possibly be a sexual character. The fishermen estimated the body of this individual to have been about 60 feet in length and 5 feet in diameter, but if the above proportions be correct, as I believe, then the body could not have been more than about 10 feet long, and 2·5 feet in diameter, and the long arms should have been about 32 feet in length. Allowing 2 feet for the head, the total length would, therefore, be 44 feet.

Another specimen (No. 3), probably of the same species, and similar in size to the last, was captured at Coombs' Cove, Newfoundland. The following account has been extracted from a newspaper article of which I do not know the precise date, forwarded to me by Professor Baird, together with a letter, dated June 15, 1873, from T. R. Bennett, Esq., of English Harbor, N. F., who states that he wrote the article, and that the measurements were made by him, and are perfectly reliable.

"Three days ago, there was quite a large squid ran almost ashore at Coombs' Cove, and some of the inhabitants secured it. The body measured 10 feet in length and was nearly as large round as a hogshead. One arm was about the size of a man's wrist, and measured 42 feet in length; the other arms were only 6 feet in length, but about 9 inches in diameter, very stout and strong. The skin and flesh were 2·25 inches thick, and reddish inside as well as out. The suction cups were all clustered together, near the extremity of the long arm, and each cup was surrounded by a serrated edge, almost like the teeth of a hand-saw. I presume it made use of this arm for a cable, and the cups for anchors, when it wanted to come to, as well as to secure its prey, for this individual, finding a heavy sea was driving it ashore, tail first, seized hold of a rock and moored itself quite safely until the men pulled it on shore."

It would appear from this description, that one of the long arms had been lost before the capture. The large diameter of the short arms, compared with their length, and with the size of the long arms, is the only point in which this specimen apparently differed essentially from those described above. Possibly the *circumference* was intended,[11] which would make the proportions agree well with those of the other specimens.

In a letter from Mr. Harvey, dated Dec. 10, 1873, he says that

[10] The photograph shows that the suckers had been much injured, and only six of the larger ones remained.

[11] A similar mistake actually occurred in the description of the long arms, in the letter from Mr. Murray, published in the AMERICAN NATURALIST for February, 1873, p. 122, referred to above, but in that instance the error was very obvious.

the speaker of the House of Assembly stated to him that he had measured a specimen cast ashore in Fortune Bay, which was between 42 and 43 feet in length, the body and head together being between 12 and 13 feet, and the two long arms each 30 feet. This we may designate as No. 6.

Dr. Honeyman, Geologist of Nova Scotia, has published in a Halifax paper, a statement made to him by a gentleman who claims to have been present at the capture of another specimen (No. 7) in the Straits of Belle Isle, at West St. Modent, on the Labrador side. "It was lying peacefully in the water when it was provoked by the push of an oar. It looked fierce and ejected much water from its funnel; it did not seem to consider it necessary to discharge its sepia, as mollusca of this kind generally do, in order to cover their escape." * * * * "The length of its longest arm was 37 feet; the length of the body 15 feet; whole length 52 feet. The bill was very large. The suckers of its arms or feet, by which it lays hold, about 2 inches in diameter. The monster was cut up, salted, and barrelled for dog's meat." In this account the length given for the "body" evidently includes the head also. This creature was probably disabled, and perhaps nearly dead, when discovered at the surface, and this seems to have been the case with most, if not all, of the specimens hitherto seen living. Animals of this sort probably never float or lie quietly at the surface when in good health. The specimen last described (No. 7) may, possibly, have belonged to *A. princeps*, if the length of the body be correctly stated.

Mr. Harvey also refers to a statement made to him by a clergyman, Rev. M. Gabriel, that two specimens (Nos. 8 and 9), measuring respectively 40 and 45 feet in total length, were cast ashore at Lamaline, on the southern coast of Newfoundland, in the winter of 1870–71. These may also have been of the same species as those described above, all of which I now refer to *Architeuthis monachus* of Steenstrup.

NOTE.—Since the above has been in type, Mr. Kent's paper, referred to on page 24 has been received by the editors of the "American Journal of Science," and will be again noticed in our next article.

[*To be continued.*]

LIFE HISTORIES OF THE PROTOZOA.

BY A. S. PACKARD, JR.

IV. THE LABYRINTHULÆ.

We would not pass over certain forms doubtfully referred to the Protozoa, by Cienkowski, the only one who has studied them, and placed by Hæckel near the Diatoms and Desmids, in his

Fig. 12.

Labyrinthula.

kingdom "Protista," but which may be provisionally located near the Rhizopods. These organisms were found by Cienkowski at Odessa beneath the seaweeds growing on the piles in the harbor. They are minute, orange-colored organisms, forming reticulated threads which enclose spindle-shaped nucleated bodies. Fig. 12, represents *Labyrinthula macrocystis*, highly magnified, with the single spindle-shaped bodies starting out from the mass on the left, and gliding over the "rope walk," or framework of threads. Cienkowski gives the following results of his investigations on the nature of these singular organisms, which we hope may be discovered in this country:

1. They present masses of cells which enclose a nucleus, and which increase in number by division; they possess a certain degree of contractility, and now and then are covered with a cortical substance.

2. These cells exude a fibrous substance, which makes a stiff, tree-like network, forming a branching framework.

3. The cells leave the mass and glide in different directions along the framework to the periphery of the mass. The Labyrinthula cells can only continue their peregrinations when supported by this line of threads.

Development. The moving cells unite in a new mass and become cysts, in which each cell is surrounded by a hard covering, the whole being held together by a rind-like substance.

After some time four small granules are formed from each cyst, which most likely become young Labyrinthula cells.

He concludes that "these peculiar organisms bear no relation to any known group of beings of either of the organic kingdoms. They cannot be classed with the sponges, Rhizopoda, Gregarinæ, or ciliated Infusoria, or with the algæ or fungi."

LITERATURE.

Cienkowski. Ueber die Bau und Entwicklung der Labyrinthuleen. (Schultze's Archiv, 1867. Abstract in Quart. Journ. Micr. Science, 1867.)

V. THE FLAGELLATA.

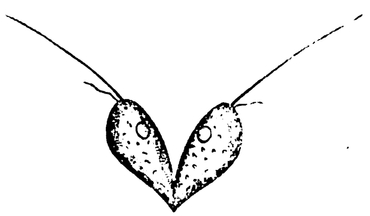
As with the Amœba-stage of the lower Protozoa, so we have had anticipations of the Monads, as the Flagellata may be popularly styled, in the zoospores of the lower Protozoa and Monera. The monads in point of structure are scarcely more highly organized in their lowest forms than the spores of the algæ and the zoospores of the other Protozoa, for which they are often mistaken. They are exceedingly minute, oval bodies, with a nucleus and contractile vesicle and one or two long whip-like cilia, whence the term *Flagellata.*

The true monads have been studied by the late Professor H. J. Clark with more success than by any one else. *Monas termo* Ehr.? is much like single individuals of *Urella glauconia* Ehr.? (Fig. 13), though the body is shorter and more regularly oval. It is faint olive in color. The monads are provided with one or more flagella, or bristle-like cilia, situated in *M. termo* on the front near the beak-like prolongation of the body. In swimming the monad stretches out the flagellum, which "vibrates with an undulating, whirling motion, which is most especially observable at its tip, and produces by this mode of propulsion the peculiar rolling of the body, which at times lends so much grace to its movements as it glides

from place to place" (Clark). When the monad is fixed the flagellum is used to convey food to the mouth, which lies between the base of the flagellum and beak, or "lip," as Clark calls it. The food is thrown by a sudden jerk and with precision, directly against the mouth. "If acceptable for food, the flagellum presses its base down upon the morsel, and at the same time the lip is thrown back so as to disclose the mouth, and then bent over the particle as it sinks into the latter. When the lip has obtained a fair hold upon the food, the flagellum withdraws from its incumbent position and returns to its former rigid, watchful condition. The process of deglutition is then carried on by the help of the lip alone, which expands latterly until it completely overlies the particle. All this is done quite rapidly, in a few seconds, and then the food glides quickly into the depths of the body, and is enveloped in a digestive vacuole, whilst the lip assumes its usual conical shape and proportions."

All the monads have a contractile vesicle. In *Monas termo*, Clark observes that it is "so large and conspicuous that its globular form may be readily seen, even through the greatest diameter of the body; and contracts so vigorously and abruptly, at the rate of six times a minute, that there seems to be a quite sensible shock over that side of the body in which it is embedded." The contractile vesicle is thought to represent the heart of the higher animals. The reproductive organ may possibly, says Clark, be represented in *Monas termo*, by a "very conspicuous, bright, highly refracting, colorless oil-like globule which is enclosed in a clear vesicle" called the nucleus. This and other monads live either free, or attached by a slender stalk. As an example of the compound or aggregated monads may be cited *Urella*

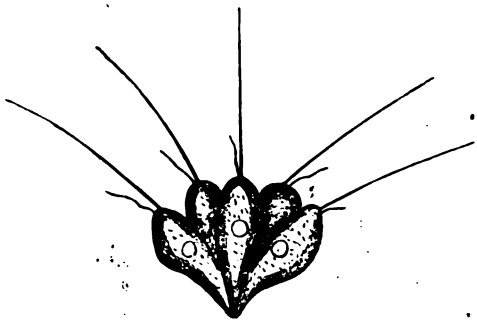
Fig. 13.



Urella.

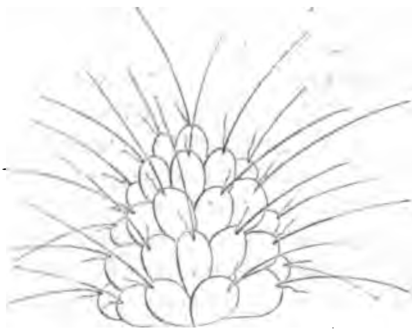
(Fig. 13), probably *glauconia* of Ehrenberg, of which an account, with accompanying figures, here reproduced, was published by Prof. A. H. Tuttle in the AMERICAN NATURALIST, vi, 286. Figs. 13, 14 and 15 represent two, five, and about forty monads of this species, magnified 1000 diameters. Fig. 16 is an ideal section through a colony of this monad. Urella, as Tuttle observes, "probably

Fig. 14.



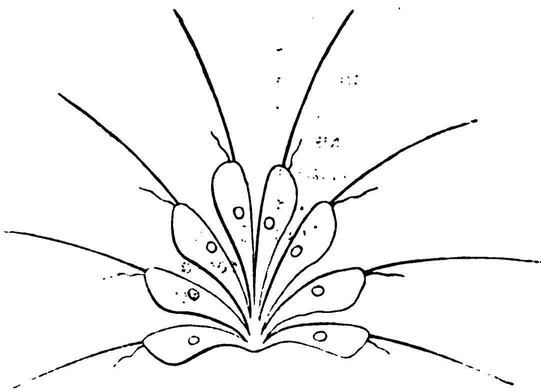
A group of five Monads (Urella).

Fig. 15.



A colony of about forty Monads (Urella).

Fig. 16.



Ideal section through a colony of Urellæ.

finds its nearest ally in Anthophysa, differing from that genus principally in being free swimming instead of fixed upon a stalk." The genera Chlamydomonas and Colpodella are represented at Fig. 20, B. A higher form than Monas is Codosiga (Fig. 17) in which the oval body is stalked and continued in front into a very high membranous bell-shaped collar. Other monads are certain human parasites, *i.e.*, *Cercomonas urinarius*, *C. intestinalis* and *Trichomonas vaginalis*.

The second family of monads are the *Astasiœa*. Here belong Astasia and Euglena (Fig. 18). The former genus is somewhat amœba-like in the changes which it undergoes, its body, according to Clark, during its amœboid retroversions becoming "contorted into a shapeless, writhing mass." They have a conspicuous, red so-called "eye-spot." A similar organ occurs in the zoospores of some algæ.

The third family of Flagellata, the *Peridinea*, is represented by Heteromastix, Dysteria, Pleuronema, Peridinium and Ceratium. Clark observes that Heteromastix is a transitional form connecting the Flagellata with the Ciliata or true Infusoria. Dysteria is still nearer to the Infusoria. Clark describes it as a two-shelled infusorian, with the open space between the shells provided with "a row of closely set, large vibratile cilia," with one larger than the others, the true flagellum. After a careful description of this organism he concludes that "in all the organization of this animal there is nothing which is not strictly infusorian in character. The jaw-like bodies are not confined to this alone, for there are quite a number of others which possess a similar apparatus at or near the mouth. Chilodon has a complete circle of straight rods around the mouth. As for the pivot it is nothing but a kind of stem, such as exists on a larger scale in Stentor, or is more particularly specialized in the pedestals of Epistylis, Zoothamnium, or Podophrya; and as counter to what we see in these last, I would state that there are certain of the Vorticellians closely related to Epistylis, which have no stem whatever, and swim about as freely as Dysteria."

The Monads are divided into three families, thus characterized by Claus in his "Grundzuge der Zoologie:"

1. *Monadina.* Body small, rounded, naked or with a tough membrane; resembling the zoospores of algæ, etc.

2. *Astasiœa.* Body naked and changeable like the monads, only bearing flagella.

3. *Peridinea.* Body having, besides the flagellum, a row of cilia.

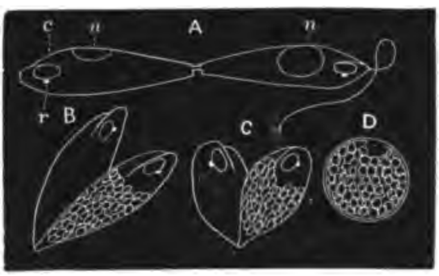
Development. The common form of reproduction is by simple self-division. Clark describes this as he observed it in *Codosiga pulcherrimus* (Fig. 17, A). The act requires forty minutes. The first sign of fission is a bulging out of the collar, which becomes still more bell-shaped. The flagellum next disappears. Then marks of self-division appear in a narrow, slight furrow (Fig. 17, B, *e*), extending from the front half-way back along the middle of the body. Meanwhile the collar, which had become conical, expands, and, most striking change of all, two new flagella appear. Then the collar splits into two (Fig. 17), and soon the two new Codosigæ become perfected, when they split asunder, and become like the original Codosiga. Such is the usual mode of multiplication of the species in the monads.

Fig. 17.

Fission of Codosiga.

A second mode, that of becoming encysted, has been rarely observed. Carter, so far as we are aware, was the first to attempt to trace the life history of a monad. We copy the following figures from his memoir. Fig. A represents two *Euglena viridis* in conjunction; *n*, the nucleus, *c*, contractile vesicle, and *r*, the red body; B and C the same after the breaking up of the contents into the embryonic zoospores. The two Euglenæ finally

Fig. 18.



Development of Euglena viridis.

separate and each becomes spherical, encysted as at D. Fig. 18 illustrates the mode of development in *Euglena agilis.* A repre-

sents the adult Euglena, taken from the brackish water of marshes at Bombay; B, the resting stage, transverse division having taken place, and showing that the red body is not developed in the lower

Fig. 19.

Development of Euglena agilis.

half; D, the same, with a quadruple longitudinal division, showing that the red body is equally multiplied; E, linear development, probably by longitudinal division, as the red body is present in each cell.

We copy a portion of the figures and account of the development of *Colpodella pugnax* as given by Cienkowski. Figure

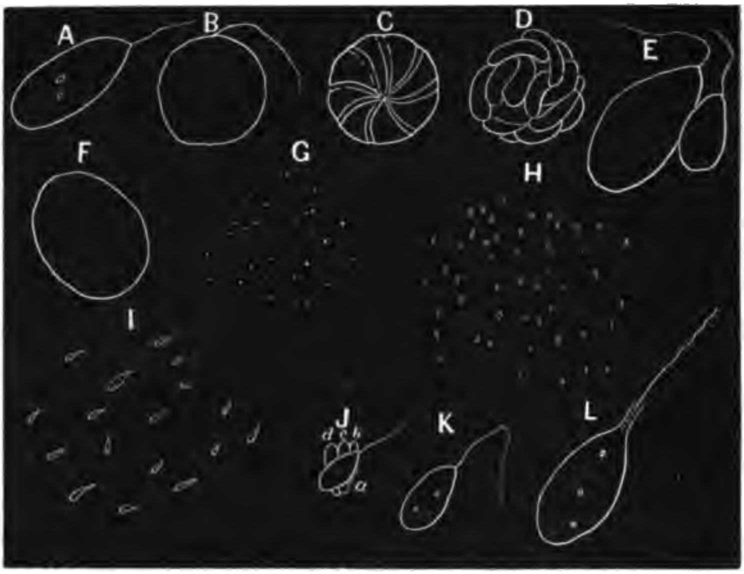
Fig. 20.

Development of Colpodella.

20, A, represents this monad before taking food; B represents three Colpodellæ in the act of absorbing the nucleus of a Chlamydomonas; at C is a single Colpodella, without the nucleus, and much swollen anteriorly. Finally the Chlamydomonas is, as it were, eviscerated, nothing but the body walls being left. After this wholesale plundering of the contents of the Chlamydomonas, it then passes into a "cell" or encysted state, as at D (*a*, the mass of food, colored red). The contents of the cell then break up into a number of masses, as at E, which finally, as at F (the masses destined to change into zoospores), issue from the cyst in a mass surrounded by a thin membrane, which gradually disappears, when the free zoospores make off in every direction. G represents the encysted body of the monad, without the ball of food. He also shows that another unknown monad, a species of Bodo, and three species of Pseudospora also develop by becoming encysted.

Messrs. Dallinger and Drysdale describe in two unknown monads the process of encysting and the development of zoospores, the sarcode mass passing through a process resembling the segmentation of the egg into four, eight and many spheres, each sphere ultimately becoming a monad. The changes were noticed with greater fulness of detail in another unknown monad, Fig. 21, A. When about to pass into the encysted stage it became amœboid in its form, but still very active; at the stage B, however, it became spherical and quiet, and finally lost the flagellum,

Fig. 21.



Development of a Monad.

and the contents suddenly divided into four portions, separated by a white cruciform mark or furrow. Then an intense activity pervaded the sarcode mass, "a sort of interior whirling motion" like the rushing of water "round the interior of a hollow glass sphere on its way to the jet of a fountain," as indicated at C. This action lasted from ten to seventy minutes, when it stopped and the mass broke up into small embryonic zoospores, as at D, which began a "quick writhing motion upon each other, like a knot of eels." After remaining in this state from seven to thirty minutes, they separated and swam away. Thus far they had

passed through the ordinary mode of formation of young monads, but the authors noticed among the swarm of monads some much larger, and differing from the others in being very granular towards the flagellate end. These fastened themselves upon one of the smaller common forms, Fig. 21, E, and finally absorbed it, a process certainly analogous to, if not identical with, conjugation. It then assumed a resting condition, as at F. The sphere then opened slowly and a glairy looking fluid poured out. On careful examination of this fluid, with powers of 2500 to 5000 diameters, seven hours after emission tiny dots, semitransparent and yellowish, appeared as at G. In an hour and ten minutes the dots appeared as at H; after two hours more as at I. The sharp-pointed bodies at I became rounder, and from the pointed end a flagellum developed as at J, when they were ninety minutes older than at I. At this time "motion first showed itself; this, however, was not the motion usual to the monad, but a motion of horizontal vibration from *a* through *b* and *c*, to *d*, and then back again." It then swam away, became plump as in K and then was followed into the stages from A to E, the last figure (L) representing the complete monad, thus passing through two cycles of existence.

Three modes of development in the Flagellata seem therefore established, as follows:—

1. Simple fission.
2. The production of monads by encysting.
3. The production of monads by encysting and conjugation, with a resting stage and the production of excessively minute zoospores which grow, finally becoming normal monads.

It will be seen that these methods of increase are paralleled by those observed in the Monera, the Gregarinida and the Rhizopoda. It appears that there is here nothing like a sexual development, unless we have something analogous to it in the conjugation (?) of the monads described by Dallinger and Drysdale, but which they themselves do not call conjugation, merely confining themselves to a statement of the facts observed by them.

LITERATURE.

Carter. Notes on the Fresh Water Infusoria of the Island of Bombay. (Annals and Magazine of Natural History, Aug. and Sept., 1856.)

Cienkowski. Beitrage zur Kenntniss der Monaden. (Schultze's Archiv, 1, 1865.)

Clark. Spongiæ Ciliatæ as Infusoria Flagellata. (Memoirs Boston Society of Nat. Hist., 1867.)

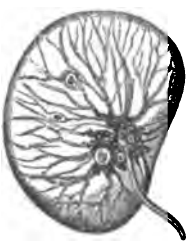
Dallinger and Drysdale. Researches into the Life History of the Monads. (Monthly Microscopical Journal, January and February, 1874.)

VI. THE NOCTILUCÆ.

Tossed from one place to another among the Protozoa, we have now, thanks to the researches of Cienkowski, certain grounds for placing the Noctilucæ near, if not among the Flagellata, from the resemblance of the zoospores to the monads; while they seem to form a more highly developed type. It thus appears that by a study of the mode of growth of the Protozoa, as in the rest of the animal world, we can alone obtain correct ideas as to the affinities of the respective groups.

The Noctiluca (Fig. 22) is a highly phosphorescent organism, so small as scarcely to be seen with the naked eye, being from ·01 to ·04 inch in diameter. It occurs in great numbers on the surface of the sea. It has a nearly spherical jelly-like body, with a groove on one side from which issues a curved filament, used in locomotion. Near the base of this filament is the mouth, having on one side a tooth-like projection. Connecting with the mouth is an œsophagus which passes into the digestive cavity, in front of which lies an oval nucleus. Beneath the outer skin or firm membrane surrounding the body is a gelatinous layer, containing numerous granules. A network of granular fibres arises from the granular layer; these fibres pass into the middle of the body to the nucleus and digestive cavity.

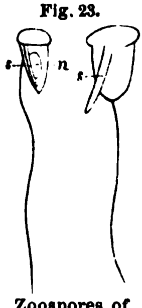
Fig. 22.



Noctiluca miliaris.

Development. Baddely had noticed a multiplication by division and reproduction by internal buds, and Busch had observed round, transparent disks, of the same size, consistence and optical properties as the Noctilucæ occurring among them, but could not determine what relations they bore to the former. It was, however, reserved for Cienkowski to trace the development of monad-like zoospores in these reproductive bodies. Fig. 23 represents these zoospores. They move about by a long flagellum. The tooth-like process (*s*) is thought by Cienkowski to be a rudimentary condition of the "whip" near the mouth of the adult Noctiluca. By keeping specimens in a drop of water on a thin glass which was placed over a moist chamber so as to ex-

Fig. 23.



Zoospores of Noctiluca.

clude all access of dry air to the water in which the animals were living, he was enabled to observe them for twelve hours. The stages he observed were—

"1st. Noctiluca-like bodies, but without mouth or lash, and having a doubly spherical or so-called biscuit form, each partial sphere having a granular protoplasmic mass with fine branching rays, the two masses being connected more or less. 2d. The protoplasm connects so as to form a disk on one pole of the irregular double spheroid, which gradually becomes spherical, exhibiting three or four depressions at one pole. 3d. The formation of the disk is preceded by a segmentation of the entire mass of the protoplasm of the Noctiluca into two, four, eight, sixteen, etc. parts, after which the disk begins to grow up on the surface of the Noctiluca. 4th. The protoplasmic disk sends out stumpy processes which project from the surface of the spheroid and exhibit peculiar wriggling movements. 5th. The mass commences to divide into smaller pieces, the vesicle being now quite spherical. The commencement of this division was not directly observed, but later stages, in which clumps of protoplasmic matter were seen arranged at first in groups of eight; these, then, were followed carefully through their division into groups of sixteen irregular, oblong particles. These products of division appear like denser, sharply-defined masses or nuclei, lying in a less dense surrounding granular plasma. 6th. The next stage was one of the first and most commonly observed, in which the protoplasmic disk, formed as above described, has become entirely split up into small oval bodies, each ·016 millimetre long. The aggregated mass of these oval spores sometimes appears as a disk at one pole of a Noctiluca-like vesicle, or as a girdle passing round it. 7th. By high powers each oval particle is seen to have a terminal cilium, and whilst under observation many were seen to separate from the disk and swim about as free swarm-spores" (Fig. 23).

Cienkowski also observed the fusion of two Noctilucæ. "The two animals place themselves with the two so-called 'oral apertures' close to one another, and through these a protoplasmic bridge is formed, which unites the nuclei of the two individuals. Later, at the points of contact, the outlines of the two Noctiluca-vesicles fuse, and thus the double-spheroid or biscuit-shaped bladders are formed. By further fusion the pinching in of the vesicle disappears from one side, so that the vesicle becomes more nearly

spherical. Meanwhile the two nuclei become completely fused into one, retaining, however, their radiating threads and network, as in normal individuals. The cross-striped 'lashes' and the 'teeth' of the two fused Noctilucæ also disappear. All trace of the double origin of these 'copulated Noctilucæ' may pass away by the disappearance of the fold on the surface, near to which the nucleus lies, and thus a Noctiluca vesicle is formed, which is always larger than the normal Noctiluca, and seems identical with the bodies noticed by Busch, and also very probably identical with the biscuit-shaped and spherical Noctiluca vesicles in which Cienkowski has traced the formation of the swarm-spores. A direct observation of the formation of swarm-spores in the copulated forms Cienkowski was not able to obtain."

This fusion of two Noctilucæ is not, however, essential for the production of zoospores, as they appear whether conjugation has occurred or not. When it does occur, however, it seems to be of a sexual nature. Conjugation, though by no means necessary, does frequently take place, and "as in the fusion of the zoospores of Myxomycetæ, and the copulation of Actinophrys, and others, leads to an augmentation of the mass of the protoplasm." "Zoospores," he adds, "occur in quite small Noctilucæ, which certainly could not be the product of the fusion of two individuals. Sometimes the zoospores develop very rapidly whilst still in the disk, and their protoplasm becomes differentiated into a nucleus and radiating threads." Cienkowski considers that the zoospores of Noctiluca decide the systematic position which must be assigned to this organism. It seems to him that they are animals of large dimensions belonging to the division of the Flagellata.

A single mode of growth, therefore, occurs in Noctiluca, *i.e.* development from zoospores.

LITERATURE.

Busch. Das Meerleuchten und die Noctiluca (in Beobachtungen über Anatomie und Entwicklung einiger wirbellosen Seethiere. 1851).

Huxley. On the Structure of Noctiluca miliaris. (Quart. Journal Mic. Sci., 1855.)

Quatrefages. Observations sur les Noctiluques. (Annales des Science Nat., 1850, and Annals Nat. Hist., 1853.)

Cienkowski. Schwärmerbildung bei Noctiluca miliaris. (Schultze's Archiv, 1871. Translation in Annals and Magazine Natural History, 1871. See also 1872, p. 414.)

THE WHEELER GEOLOGICAL SURVEY OF NEW MEXICO FOR 1874.

BY E. D. COPE.

THE Engineer Topographical and Geological Survey west of the 100th meridian, under Lieut. Geo. M. Wheeler, left Pueblo during the month of July for the prosecution of their labors in New Mexico. It was divided into eight parties, of which six were primarily topographical and two devoted to geological and biological investigation.

Of the former one only, that under charge of Lieut. Blunt, operated east of the Rocky Mountains, while the remaining five surveyed from the Colorado line, or near it, southward as far as the Rio El Rito and Cañon Apache, in the following order: at the north Lieut. Marshall; then Wheeler, Whipple, Birnie, and last, Lieut. Price. The last named officer having been incapacitated by sickness was succeeded in charge by Mr. Klett. The two remaining parties were assigned extensive territorial areas, as the nature of their work required widely extended reconnoissances, as well as studies in special localities, the position of which could not be foreseen. Dr. Rothrock was in charge of a party which explored the botany and zoology of southern Arizona and New Mexico, and Dr. Yarrow and Prof. Cope investigated the geology and paleontology of the northern portion of the latter territory.

We propose to speak of the work of the last named party at present, as several of the others have not yet come in from the field. Dr. Yarrow having left for Washington about the middle of September, according to previous arrangement, the direction devolved on the writer. The results obtained have been highly interesting and important to geological science. An analysis of the structure of the region traversed between Pueblo and Santa Fé was accompanied by successful collecting of fossil remains in many of the strata. Thus the Cretaceous beds near the Huerfano yielded many fine fossil shells and teeth of extinct fishes, and the carboniferous limestone of the Sangre del Christo pass was found to be equally rich. A unique collection of a large number of most beautifully preserved invertebrate remains was procured

from the same formation near Taos. Below the Picoris Mountains the sand beds and bluffs of the Pliocene formation fill the valley of the Rio Grande. These are the deposits of a lake of comparatively modern age, and in some localities they abound in remains of the skeletons of the animals that inhabited the surrounding continent at that time. Mastodons of species quite different from that so frequently found in the Eastern states were found to be abundant, while camels and horses had evidently existed in droves. One of the most singular discoveries was that of deer which did not shed their horns, as do modern species of that type. There is abundant reason to believe that they were frequently broken off in combats, so that while some individuals of a species had solid horns like the giraffe, others of the same species had them united by a suture with a burr like the deer. To keep the herbivorous animals in check, there were several species of wild dogs, while a large vulture allied to the turkey buzzard was prepared to eat them when life had departed, as the fossil remains demonstrate.

After concluding the investigation of this basin, the geologist was enabled through the courtesy of Gen. Gregg commanding the district of New Mexico, to make an exploration of the geology of the region at the northern end of the Zandia Mountains, forty miles south of Santa Fé. Here numerous fossil remains were found, including those of the hairy elephant, *Elephas primigenius* (var. *Columbi*). The party, after examining the geology of the Eastern Jernez mountains, passed north to Abiquiu on the Rio Chama and through the cañon Canjelon to Tierra Amarilla.

The writer had been led to suspect the existence of a tertiary lake basin on the divide of the drainage of the Chama and San Juan rivers, and had already published his belief that the rich life of the Eocene period of Wyoming had been preceded by older forms, which had lived upon older territory in the southern regions of the great basin. This position was fully confirmed by my discovery in the region in question of an enormous mass of lacustrine deposits of some 3000 feet in thickness, which cover an area of at least 3000 square miles (probably more) which includes remains of the oldest mammalian fauna of the continent, and which corresponds with the lowest of the fossil bearing beds of Wyoming. About 100 species of vertebrate animals were obtained, of which two-thirds are mammalia, and a large percentage new to

science. The crocodiles were very numerous and turtles swarmed. The mammalia did not embrace many of the modern classes, but exhibit, according to the preliminary reports published by direction of Lieut. Wheeler, characters of orders of which little has been known. The largest species were those of the genus Bathmodon, of which five species were discovered, which range from the size of the Indian rhinoceros to that of the tapir. They resembled closely the elephants in the structure of the feet and legs, but the tapir and the bear in the characters of the skull. They were armed with most formidable tusks, and their crania were solid and well thickened to repel attack. Besides these there were numerous species more nearly resembling the tapirs, and in some remote degree the horses, of a more harmless type, while a numerous population of carnivora restricted the increase of the rest. Sixteen species of flesh-eating forms were found, some of them minute, and others of powerful make, but all far removed from the existing types, and more or less related in structure to other kinds of quadrupeds, especially to those of insectivorous habits. Some of them possessed teeth of extraordinary strength, and were apparently bone breakers, while the excessively worn condition of the teeth and tusks of some others indicate hard diet and friction against resisting bodies. An order of very peculiarly constructed animals was represented by several species. These had much the structure of the gnawing order (Rodentia) in their dentition, which, however, includes many peculiarities, but resembled some of the hoofed animals in their feet. The only known example of this order (the Toxodontia) had been previously obtained from the late tertiary deposits of South America.

The boundaries of this lake basin were pretty well determined, and attention directed to the structure of the hill and mountain regions which constituted its shores. Among these were found marine and fresh water formations, containing abundant fossil remains, with beds of lignite of fifty feet or more in thickness. One of the lake deposits contains an abundance of petrified wood, while a lower formation was found to contain the teeth and bones of saurians of large proportions, and apparently of greater antiquity than those heretofore obtained in the West.

The brilliant colors of some of the strata observed are very remarkable, and the scenery is rendered highly picturesque by the escarpments of obliquely elevated strata, which traverse the coun-

try for sixty miles and more, parallel to the mountain axis. Most curious are the remains of human dwellings which stand in lines on the summits of these rock crests, and almost all the more inaccessible and remote points of the hills. They were often found standing on the summits of ledges of from five to twelve feet in width, with precipices of several hundred feet in depth on one or both sides; or occupying ledges on the sides of precipices forming the walls of cañons, in positions only accessible by perilous climbing. These localities are often remote from water, in some cases more than twenty miles.

The party collected and brought within reach of transportation about a ton of fossil remains. They crossed directly from the Rio Puerco to Conejos over the San Juan Mountains by a pass some twenty miles in length, where they were overtaken by a severe snowstorm. They returned to Pueblo on the 11th of November.

REVIEWS AND BOOK NOTICES.

Embryology of the Ctenophoræ.[1] — The development of certain jelly fishes (Ctenophoræ) belonging to the genera Idyia and Pleurobrachia has been elaborated in this memoir with great care and beauty of illustration by Mr. A. Agassiz. He gives a connected account of their history from the earliest stages in the egg until all the features of the adult appear. While the mode of segmentation of the yolk is extraordinary, the embryo attains the adult form without any metamorphosis, the changes being very gradual. Mr. Agassiz's observations, with the preceding ones of Müller, Gegenbaur, Kowalevsky and Fol, give us a tolerably complete view of the mode of development of this order of jelly fishes. These Ctenophoræ on our coast spawn late in the summer and fall. The young brood developed in the autumn comes to the surface the following spring nearly full-grown, to lay their eggs late in the summer. The autumn brood most probably passes the whole winter in deep water, and it must take six to eight months for the young to attain their maturity. The memoir closes with

[1] Embryology of the Ctenophoræ. By Alexander Agassiz, with 5 plates and figures printed in the text. From the Memoirs of the Amer. Acad. Arts and Sciences, x, Aug. 1874. 4to, pp. 41.

a vigorous and trenchant criticism of Haeckel's Gastrula theory, exposing its weak points. Mr. Agassiz regards the assumptions of Haeckel forming the basis of his Gastrula theory as "wholly unsupported." It must "take its place by the side of other physio-philosophical systems," and he denies that we have been "able to trace a mechanical cause for the genetic connection of the various branches of the animal kingdom."

Entomology in Illinois.[1]—We have noticed previously the important entomological reports made by Mr. Riley to the state of Missouri; we now have before us a Report of about two hundred pages by the state entomologist of Illinois. It is fully illustrated by admirable drawings mostly from the pencil of Mr. Riley, and is well printed. Instead of treating directly of injurious insects, it is a treatise on the beetles of the United States, and as such will serve to prepare the way for future reports on economic entomology. The work is excellent as an introduction to a study of the beetles, which comprises some of the most injurious species, and we bespeak for it a large circulation outside of the state. We could find some fault with the general classification of the insects, but the aim of the work and successful treatment of the subject preclude such criticism. The transformations of a number of new beetles are described and figured.

Polarization of Light.[2]—This is another of the elegant and popular treatises reprinted with additions and new plates from "Nature." They contain the substance of lectures delivered at various times to workpeople, and "constitute a talk rather than a treatise on polarized light," says the author.

BOTANY.

Do Varieties wear out or tend to wear out?—In an interesting article on this subject in the New York "Tribune," Prof. Gray discusses this question, and concludes that "sexually propagated varieties, or races, although liable to disappear through change, need not be expected to wear out, and there is no proof that they do; also, that non-sexually propagated varieties, though

[1] Fourth Annual Report on the Noxious and Beneficial Insects of the State of Illinois. By William LeBaron, M.D. Springfield, 1874. 8vo, pp. 199.

[2] Polarization of Light. By William Spottiswoode, LL.D., F. R. S. Nature Series. London. Macmillan & Co. 1874. 12mo, pp. 129, with plates and cuts. Price $1.00.

not liable to change, may theoretically be expected to wear out, but to be a very long time about it."

Cypripedium spectabile.—Last spring I found on East Mountain, Williamstown, two flowers of the *Cypripedium spectabile* Swartz, growing from the same stalk, one of which was the regular color, nearly all purple, and the other was pure white.—J. S. Kingsley.

ZOOLOGY.

Note on Sterna longipennis Nordmann.—In the Naturalist for July, 1874 (p. 433), a tern, "new to the Atlantic coast of North America," was described by me under the name of *Sterna Portlandica*—in event it should prove distinct from *S. longipennis* Nordm., with which Dr. Coues identified Mr. Lawrence's *S. Pikei* (see Key, p. 320). At that time no specimen of Nordmann's species existed, so far as known, in the United States, so that a satisfactory comparison could not be made, while the new bird did not agree well with the description of *S. Pikei* in the ninth volume of the Pacific Railroad Reports (p. 863). In order to settle the question of the relationship of *S. Portlandica*, Dr. Otto Finsch, Curator of the Bremen Museum in Germany, kindly forwarded to the Smithsonian Institution the only specimen of *S. longipennis*, a fine example, in perfect plumage, procured at the sea of Baikal, Siberia, June 3, 1870. Having thus an opportunity of actual comparison of specimens, the results are herewith given:

Sterna longipennis Nordmann is very closely related to *S. hirundo*, from which it scarcely differs more than as a geographical race, and is very distinct from both *S. Pikei* and *S. Portlandica*. The degree of relationship between the four forms is shown below:

A.—Beneath ashy white; nape pale pearl-gray; forehead black in summer; feet red. Tarsus ·70 or more; culmen 1·40 or more.

Bill red, the terminal third black. Wing, 10·35; tail, 6·50; depth of fork, 3·10; culmen, 1·50; depth of bill, ·30; tarsus, ·80; middle toe, ·68.

S. hirundo.

Bill black, the upper mandible beneath the nostril and the basal two-thirds of the lower inclining to reddish. Wing, 10·35; tail, 6·30; depth of fork, 2·55; culmen, 1·50; depth of bill ·30; tarsus, ·75; middle toe, ·68.

S. longipennis.

B.—Beneath snowy-white; nape pure white; forehead wholly white in summer; feet black or red; tarsus ·60 or less; culmen, 1·25 or less.

Bill deep black; feet deep black. Wing, 9·60; tail, 6·00; depth of fork, 2·60; culmen, 1·15; depth of bill, ·25; tarsus, ·55; middle toe, ·60.

S. PORTLANDICA.

Bill dusky reddish; feet reddish. Wing, 9·00; tail, 5·50; culmen, 1·12; tarsus, ·50.

S. PIKEI.

S. longipennis agrees very closely with both *S. hirundo* and *S. macroura* in the main points of coloration, having the same decided grayish tinge to the lower parts and nape, and the forehead black. The specimen compared, however, differs from both these species in having the white terminal borders to the longer scapulars, tertials and inner primaries much less distinct; the outer surface of the primaries is more silvery, and the black of the nape appears to extend farther down, terminating at about 3·00 from the base of the culmen instead of at less than 2·50. Whether this last feature depends upon the "make" of the skin is uncertain.—ROBERT RIDGWAY.

GEOLOGY AND PALEONTOLOGY.

NEW FORMS OF ELASMOSAURIDÆ.—Professor H. G. Seeley has recently examined the structure of the reptiles found in the English formations referred by authors to the old genus Plesiosaurus. He finds that the modifications in the structure of the scapular arch are such as to require their reference to two families, the Plesiosauridæ and Elasmosauridæ. The former embraces only the genus Plesiosaurus; the latter includes Elasmosaurus and three new genera, namely, Eretmosaurus, Colymbosaurus and Muræno-saurus. The characters distinguishing these genera are principally discoverable in the scapular arch.—E. D. C.

AMERICAN TYPES IN THE CRETACEOUS OF NEW ZEALAND.—Mr. Hector, the paleontologist of New Zealand, has obtained and decribed the remains of numerous extinct reptiles which present various points of resemblance to those disclosed by explorations in Kansas, and described in Dr. Hayden's annual reports. Thus he finds a species of Polycotylus and a form which he states to be allied to Elasmosaurus, called Tanivasaurus. He adds a number

of species of Pythonomorpha, among which are a Liodon, with a conic muzzle, and a new genus allied to Clidastes. Other species are referred to the true Plesiosaurus.—E. D. C.

A NEW MASTODON.—The Mastodon of the Santa Fé marls turns out to be distinct from the *M. Chapmanii* of the East, and the *M. Shepardii* of California, and is allied to the *M. longirostris* of Europe. It has been named *N. productus* Cope. The presence of the genera of Mammalia characteristic of the Pliocene formations of Nebraska and Colorado refers these beds to the same horizon. A report on the paleontology of the formation is just issued by the Chief of Engineers, Washington.—E. D. C.

ANTHROPOLOGY.

CREMATION AMONG NORTH AMERICAN INDIANS.[1]—The object of the present note is merely to record the fact, that among the many different methods of paying the last tribute of respect to deceased members of the tribe, which are now practised by the native races of North America, cremation is not entirely omitted.

In December, 1850, while enjoying the hospitality of the detachment of the 2nd U. S. Infantry, which at that time established Fort Yuma, the military post at the junction of the Colorado and Gila Rivers in California, I availed myself of the kind offer of Mr. Jordan, one of the owners of the ferry near the post, to make with him an exploration of the river below the junction.

Starting in a small flat boat, which he generously sacrificed for the purpose, with a Yuma Indian, who had a feeble knowledge of Spanish, as guide and interpreter, we floated down with the current of the river, making, by the aid of a solar compass, a rough survey. On the afternoon of the third day we arrived at the lowest village of the Cocopa Indians, who are the next tribe south of the Yumas. Below that village we were told that the spring tides widely overflowed the banks of the river, and that if we went farther, the softness of the mud might seriously hinder our return.

The next day I learned from the guide that an old man had died in a village near the east bank of the river, and that the body was to be burned.

[1] Read at the Hartford Meeting Amer. Assoc. Adv. Sci.

Never having heard before that this custom existed in North America, we eagerly availed ourselves of the opportunity of seeing the interesting ceremony. Crossing the stream in our flat boat, we arrived, after a walk of a couple of miles over the river bottom and adjoining desert, at the late residence of the deceased.

A short distance from the collection of thatched huts which composed the village, a shallow trench had been dug in the desert, in which were laid logs of the mesquite (Prosopis, and Strombocarpus), hard and dense wood, which makes, as all western campaigners know, a very hot fire, with little flame, or smoke. After a short time the body was brought from the village, surrounded by the family and other inhabitants, and laid on the logs in the trench. The relatives, as is usual with Indians, had their faces disfigured with black paint, and the females as is the custom with other savages made very loud exclamations of grief, mingled with what might be supposed to be funeral songs. Some smaller faggots were then placed on top, a few of the personal effects of the dead man added, and fire applied. After a time, a dense mass of dark colored smoke arose, and the burning of the body, which was much emaciated, proceeded rapidly. I began to be rather tired of the spectacle, and was about to go away, when one of the Indians, in a few words of Spanish, told me to remain, that there was yet something to be seen.

An old man then advanced from the assemblage, with a long pointed stick in his hand. Going near to the burning body he removed the eyes holding them successively on the point of the stick, in the direction of the sun, with his face turned towards that luminary, repeating at the same time some words, which I understood from our guide was a prayer for the happiness of the soul of the deceased. After this more faggots were heaped on the fire which was kept up for perhaps three or four hours longer. I did not remain, as there was nothing more of interest, but I learned on inquiry, that after the fire was burnt out, it was the custom to collect the fragments of bone which remained, and put them in a terra cotta vase, which was kept undor the care of the family.

The ceremony of taking out the eyes, and offering them to the Sun, seems to indicate a feeble remnant of the widely diffused Sun worship of former times, but when introduced, or whence derived, I could not learn. The subject appears to me an important

one, and to deserve attention from those who are so situated as to procure further information.

None of the Cocopas whom I met had sufficient knowledge of Spanish to enable me to communicate easily with them, so that I learned little of their history or habits, during the two days that I remained among them. I however wrote down their numerals and a few other words, which were sufficient to confirm the information I afterwards obtained.

On a subsequent journey along the Gila to Tucson and other towns, then belonging to the Mexican state of Sonora, I passed through the villages of the Coco-maricopas who, as is well known to all of my hearers, live in a semi-civilized condition, in close bonds of union with the Pimos, on the banks of the Gila.

I was led by the similarity of language, as well as by the resemblance in name, to suspect that this tribe was related to the Cocopas of the lower Colorado. On enquiring, I was told by one of the chiefs, Francisco Duk, that they still preserved a tradition of the former connection of the two tribes. Many years ago, in search of more extensive lands, the Cocopas had separated from them, and gone westward, settling on the banks of the Colorado, below the confluence of the Gila. Visits were occasionally made to their villages by their kinsmen from the Colorado, and in fact, I had met on my journey a small party of Cocopas returning from the Maricopa villages.

The Maricopas are now completely identified in interests and habits with the Pimos, and if they practised cremation when they first entered the Gila valley, the usage has long since become obsolete.

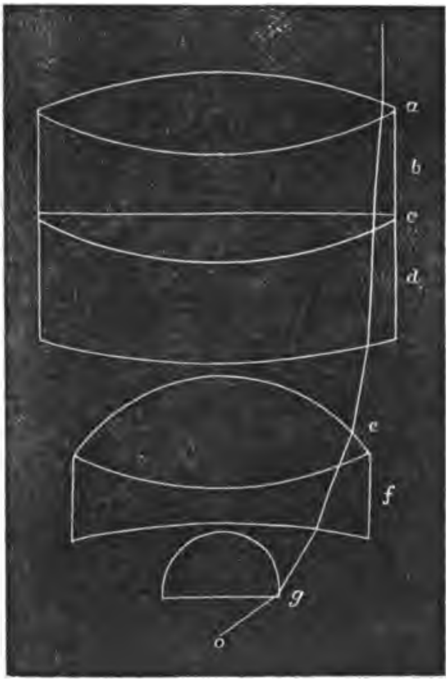
Commercial intercourse between the Indians of these interior valleys and those of the Californian Gulf must have also taken place centuries ago, when a higher form of semi-civilization existed along the Gila. For not many days afterwards while examining the famous Casas Grandes or Casas Blancas, as they are more usually called, I found shells of the genera Oliva and Conus, which had been brought from the Gulf. Small ornaments of turquoise, similar to the variety found near Santa Fé, New Mexico, occasionally occur and are greatly prized by the Indians.

MICROSCOPY.

ANGULAR APERTURE.—The discussion upon this question which was tedious a year or two ago has become interesting now, and the utilization of the extra-limital rays (in immersion objectives as compared with dry ones) which was first published as a definite theory by Dr. Woodward, in the "Monthly Mic. Journ.," and editorially in the NATURALIST, in an article which was written independently, and was in type at the same time, seems likely to prove to be one of the few great steps of progress in the development of the microscope. Before that time Mr. Wenham, and some others, had strenuously insisted upon teaching the reduction of the (nearly) 180° dry angle to about 82° immersion angle, and in so doing had been led, apparently unconscious of saying materially more than that, into a denial of the possibility of constructing an objective capable of using a larger angle than that; and Mr. Tolles, and no others, had as firmly insisted on his ability to enlarge the angle without any definite or assignable limit: the one party had argued a natural limit and nothing further, and the other party had denied a limit and appealed to his work for proof, but neither party was understood to have established the doctrine of the utilization of the extra-limital rays by admitting the limit, and at the same time showing how that limit may be passed without conflicting with well established theory. When this explanation was published it seemed so reasonable and so consistent with the assertions of both parties, that it was supposed both would say that it was precisely what they meant all the time. Mr. Tolles promptly did this, but Mr. Wenham, to the surprise of many of his friends, denied and still denies the whole doctrine, and what is more strange is satisfied with a measurement of one of Mr. Tolles' glasses as a final disproof of so fundamental and important a theory. The exact angle of a certain $\frac{1}{6}$ made by Mr. Tolles, and whether it exceeds 82° or not, is of some consequence to Mr. Tolles and his customers, but is of little importance to the world of science, compared with the theoretical possibility of exceeding that limit; and Mr. Wenham is, perhaps, one of the last persons in the world who would have been expected to fall into any doubt or confusion at this point. At the same time as Mr. Tolles was the first, and still is the only

one known to claim to make lenses in which the extra-limital rays are turned to good account, it is only justice to him to mention his name in connection with them, just as Huyghens and Kellner are credited with the negative and orthoscopic oculars, and Wenham with the binocular prism and the simple front objective. The exact comparative efficiency of the extra-limital immersions is yet undetermined, though they would be expected to have certain strong working points; a theory that seems fully justified, even

Fig. 24.



after making all possible allowance for the enthusiasm of those possessing and using a novelty, by the trials already made of some of the lenses.

Of all the contributions to this subject none probably excel in interest and importance the mathematical computation of the course of the light through the $\frac{1}{10}$ inch objective at the Army Medical Museum, by Prof. R. Keith, of Georgetown, a synopsis of which was published in the September Number of the "Monthly Microscopical

Journal," and for the full details of which we are indebted to the courtesy of Prof. Keith. Nor is the interest of this elaborate mathematical analysis appreciably lessened by Mr. Wenham's doubt, as to the reliability of the data furnished by Mr. Tolles as a basis for the computation; since if the data do not accurately represent the construction of that objective they at least seem to represent a practicable combination of lenses, which might be made into an objective, and that is what we want to know, and what the long discussion has derived its cat-like life from. The objection in question consists of seven lenses; a quadruple back consisting of a double-convex of crown glass, a plano-concave of flint, a plano-convex of crown and a meniscus of flint, a double middle formed by the union of a double-convex of crown and a double-concave of flint, and a simple hemispherical front of crown. The plan of grinding the lenses as thin as possible is discarded, as in much recent work, and some of the lenses are quite thick at the thinnest point. The following figures represent the data of construction, the letters *a* to *g* representing the seven lenses in regular order, beginning with the upper lens of the back combination (See also Fig. 24).

	a.	b.	c.	d.	e.	f.	g.
Index of Refraction.	1·525	1·620	1·525	1·620	·525	1·654	1·525
Radius of Curvature:							
First surface.	·265	·2	∞	·2	·1	·18	·033
Second surface.	·2	∞	·2	·5	·18	·5	∞
Thickness at centre.	·048	·027	·033	·047	·062	·02	·035
Diameter.	·2	·2	·2	·2	·165	·165	·066

Distance of back combination from middle ·008. By screw collar adjustment the front is set at a distance of ·00528 from the next surface. The light is assumed to start from a point ten inches above the first (back) surface, and is traced through the objective to a focal point below. The table on p. 62 represents the distance from the axis at which the extreme ray crosses each surface, and the angles which the ray, before crossing, makes with the axis. The negative sign indicates convergence of light.

This gives a computed angular aperture of 110° 35′ 10″, which largely exceeds the 87° obtained by measurement by Dr. Wood-

ward; but the very reasonable allowance of ·00162 for the setting of the front lens, reduces the computed to the observed angle. By computation the spherical aberration is almost nothing, which also corresponds with Dr. Woodward's statement, based upon the performances of the lens in actual use. Though constructed for immersion use only, Dr. Woodward states that it works well dry at near open point.

First surface.	0·09250	+ 0° 31′ 45″
Second "	0·09139	— 6 51 51
Third "	0·08742	— 4 37 23
Fourth "	0·08626	— 4 54 42
Fifth "	0·08318	— 2 57 30
Sixth "	0·07391	— 11 1 3
Seventh "	0·06625	— 24 37 5
Eighth "	0·05324	— 20 8 0
Ninth "	0·03300	— 29 44 7
Tenth "	0·00000	— 55 17 35

TOLLES' NEW $\frac{1}{10}$TH *vs.* OLD $\frac{1}{50}$TH.[1]—I am indebted to my friend Mr. J. Edwards Smith, of Ashtabula, O., for the loan of his old Tolles' $\frac{1}{50}$th, the first lens, so far as I know, that showed *A. pellucida* in dots, and also his new Tolles' $\frac{1}{6}$th objective. Both glasses failed in my hands, with eye-pieces as high as Beck's No. 3, to do as well as my Tolles' 3 system $\frac{1}{50}$th: but the performance of the $\frac{1}{6}$th was so very fine for a glass of such low power, that I at once ordered one of like construction; thinking that such a glass could be relied upon in the study of objects too thickly covered to permit the use of the higher-power objective.

The one sold me by Mr. Stodder is marked "Tolles' $\frac{1}{10}$th Immersion, Balsam angle 88°." Its air angle, as billed by Mr. Stodder, is 180°. It works well through the covers generally used for test objects.

I was greatly surprised at the exquisite performance of this glass. The best work of the $\frac{1}{50}$th, either by day or lamplight illumination, was at once excelled; the advance being of so decided a character as not to permit of doubt.

A certain Lepisma scale that I had carefully studied for a long

[1] Read before the Memphis, Tenn., Microscopical Society, Dec. 3d.

time with the $\frac{1}{50}$th and other glasses, and had seen under many favorable conditions, was instantly displayed by the four-system $\frac{1}{10}$th clearer and better in every respect than I had before seen it. With this superb definition it appeared in ridges and corrugations, not beads; thus confirming the conclusions arrived at previously.

The superiority of the new glass is also evident on the most difficult natural tests known, such as *A. pellucida*, *N. crassinervis*, *F. saxonica* and *Nitzschia curvula*, the transverse striæ showing well, by lamplight, on all of them whether mounted dry or in balsam. The longitudinal lines of *Suirella gemma* are strongly seen; and such coarsely marked shells as *P. angulatum*, are splendidly illustrated with central light. This method of illumination readily brings to view the minute hexagons of *Triceratium favus* in balsam, a more difficult test than *angulatum;* and also shows *S. gemma* well broken up.

An exquisite definition of the scales of *Podura* and *Degeeria*, gives no semblance of beading, although the ridges are better defined than I have ever seen them before.

For an eminent optician to surpass his own best glasses of the highest powers, with objectives of an improved plan of construction and of as low power as $\frac{1}{10}$th, is surely a triumph worth recording, and gives promise of still further advance.—G. W. MOREHOUSE, *Wayland*, *N. Y.*, *Nov.*, 1874.

REMARKS ON MR. MOREHOUSE'S PAPER.[1] — Referring to Mr. Morehouse's observations on *Podura* and *Lepisma*, I desire to say that I have diligently studied these scales with the new 4 system $\frac{1}{6}$th and $\frac{1}{10}$th objectives, and that I thoroughly endorse what he has written. I have never discovered the slightest semblance of the "beading" set forth by some observers. With the objective out of proper correction, it is indeed easy to get appearances that might mislead a novice.

Regarding the performance of the $\frac{1}{6}$th, I beg to add, that its maximum cannot be obtained with eye-pieces less than a *D* solid. Even when employing lamp illumination, I often get "decided added force" by using the $\frac{1}{4}$th inch solid (=F). With blue sunlight the $\frac{1}{6}$th will bear the $\frac{1}{8}$th inch solid effectively.—J. EDWARDS SMITH, *Ashtabula*, *O.*, *Nov.*, 1874.

[1] Read before the Memphis Microscopical Society, Dec. 3d.

NOTES.

"The Natural History Association of North-western College," at Naperville, Illinois, has recently completed its organization. The following are the officers:—J. L. Rockey, President; A. Goldspohn, Vice President; J. W. Troeger, Secretary; C. F. Rassweiler, A. M., Treasurer; Professor H. H. Rassweiler, Curator; Miss N. Cunningham, Directress of the Botanical Department; C. H. Dreisbach, Director of the Mineralogical and J. W. Troeger, of the Zoological Departments.

Those who remember the ingenious section cutter figured and described in a late number of the Naturalist will be pleased to know that L. Schrauer, 13 Edgerly Place, Boston, has the patterns, and can furnish them to order. He has made one for the Botanic Gardens, Cambridge, and it works admirably. He is endeavoring to establish a business in this branch of work including microscope stands and apparatus connected with it, and we can highly commend his work.— E. S. Morse.

[We cordially recommend Mr. Schrauer as an excellent workman.—Editors.]

The skeletons of five Indians were recently exhumed by several members of the Essex Institute, in Marblehead. A farther account will appear in our next number. The skeletons were photographed in situ, and copies of the photographs are for sale by the Naturalists' Agency.

The undersigned is about to publish his long projected monograph of Geometrid moths, and designs giving a figure of each species. To make the work as complete as possible specimens of this family are earnestly desired for study and will be carefully returned, or other specimens sent in exchange.—A. S. Packard, Jr.

EXCHANGES.

Mounted Microscopic Objects wanted in exchange for handsomely illustrated Geological Reports. Address Rev. I. F. Stidham, 171 South 3d Street. Columbus. Ohio.

Pacific Algæ in exchange for specimens from the Atlantic coast of the United States. Address Rev. A. B. Hervey, 10 North Second Street, Troy, N Y.

Wanted. A small quantity of the New or West Nottingham diatomaceous earth (or information in regard to locality). A good exchange offered. Address Frank Miller' P. O. Box 142, East New York, Kings County, N. Y.

THE

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ON THE CLASSIFICATION OF THE ANIMAL KINGDOM.[1]

BY PROFESSOR T. H. HUXLEY.

LINNÆUS defines the object of classification as follows:—"Methodus, anima scientiæ, indigitat, primo intuitu, quodcumque corpus, naturale, ut hoc corpus dicat proprium suum nomen, et hoc nomen quæcumque de nominato corpore beneficio seculi innotuere, ut sic in summa confusione rerum apparenti, summus conspiciatur Naturæ ordo." ("Systema Naturæ," ed. 12, p. 13.)

With the same general conception of classificatory method as Linnæus, Cuvier saw the importance of an exhaustive analysis of the adult structure of animals, and his classification is an attempt to enunciate the facts of structure thus determined, in a series of propositions of which the most general constitute the definitions of the largest, and the most special, the definitions of the smallest groups.

Von Baer showed that our knowledge of animal structure is imperfect unless we know the developmental stages through which that structure has passed; and since the publication of his "Entwickelungs-Geschichte der Thiere," no philosophical naturalist has neglected embryological facts in forming a classification.

Darwin, by laying a novel and solid foundation for the theory

[1] Paper read at the Linnean Society, Dec. 4, 1874. Printed from advance proofs corrected by the author.

of evolution, introduced a new element into taxonomy. If a species, like an individual, is the product of a process of development, its mode of evolution must be taken into account in determining its likeness or unlikeness to other species; and thus "phylogeny" becomes not less important than embryogeny to the taxonomist. But while the logical value of phylogeny must be fully admitted, it is to be recollected that in the present state of science absolutely nothing is positively known respecting the phylogeny of any of the larger groups of animals. Valuable and important as phylogenic speculations are as guides to, and suggestions of, investigation, they are pure hypotheses incapable of any objective test; and there is no little danger of introducing confusion into science by mixing up such hypotheses with taxonomy, which should be a precise and logical arrangement of verifiable facts.

The present essay is an attempt to classify the known facts of animal structure, including the development of that structure, without reference to phylogeny, and, therefore, to form a classification of the animal kingdom which will hold good, however much phylogenic speculations may vary.

Animals are primarily divisible into those in which the body is not differentiated into histogenetic cells (Protozoa), and those in which the body becomes differentiated into such cells (Metazoa of Hæckel).

I. The Protozoa are again divisible into two groups: 1. the Monera (Hæckel), in which the body contains no nucleus; and 2. the Endoplastica, in which the body contains one or more nuclei. Among these the Infusoria, Ciliata and Flagellata (*e.g.*, Noctiluca), while not forsaking the general type of the single cell, attain a considerable complexity of organization, presenting a parallel to what happens among the unicellular Fungi and Algæ (*e.g.*, Mucor, Vaucheria, Caulerpa).

II. The Metazoa are distinguishable, in the first place, into those which develop an alimentary cavity—a process which is accompanied by the differentiation of the body wall into, at fewest, two layers, an epiblast and a hypoblast (*Gastræœ* of Hæckel), and those in which no alimentary cavity is ever formed.

Among the Gastrææ there are some in which the gastrula, or primitive sac with a double wall open at one end, retains this primitive opening throughout life as the egestive aperture; numerous

ingestive apertures being developed in the lateral walls of the gastrula—whence these may be termed Polystomata. This group comprehends the Spongida or Porifera. All other Gastræa are Monostomata, that is to say, the gastrula develops but one ingestive aperture. The case of compound organisms in which new gastrulæ are produced by germination is of course not a real exception to this rule.

In some Monostomata the primitive aperture becomes the permanent mouth of the animal (Archæstomata).

This division includes two groups, the members of each of which are very closely allied:—1. The Cœlenterata.. 2. The Scolecimorpha. Under the latter head are included the Turbellaria, the Nematoidea, the Trematoda, the Hirudinea, the Oligochæta, and probably the Rotifera and Gephyrea.

In all the other Monostomata the primitive opening of the gastrula, whatever its fate, does not become the mouth, but the latter is produced by a secondary perforation of the body wall. In these Deuterostomata there is a perivisceral cavity distinct from the alimentary canal, but this perivisceral cavity is produced in different ways.

1. A perivisceral cavity is formed by diverticula of the alimentary canal, which become shut off from the latter (Enterocœla).

The researches of Alexander Agassiz and of Metschnikoff have shown that, not only the ambulacral vessels, but the perivisceral cavity of the echinodermata are produced in this manner; a fact which may be interpreted as indicating an affinity with the Cœlenterates (though it must not be forgotten that the dendrocœle Turbellaria and many Trematoda are truly "cœlenterate"), but does not in the least interfere with the fundamental resemblance of these animals to the worms.

Kowalevsky has shown that the perivisceral cavity of the anomalous Sagitta is formed in the same way, and the researches of Metschnikoff appear to indicate that something of the same kind takes place in Balanoglossus.

2. A perivisceral cavity is formed by the splitting of the mesoblast (Schizocœla).

This appears to be the case in all ordinary Mollusca, in all the polychætous Annelida, of which the Mollusca are little more than an oligomerous modification, and in all the Arthropoda.

It remains to be seen whether the Brachiopoda and the Polyzoa belong to this or the preceding division.

3. A perivisceral cavity is formed neither from diverticula of the alimentary canal nor by the splitting of the mesoblast, but by an outgrowth or invagination of the outer wall of the body (Epicæla).

The Tunicata are in this case, the atrial cavity in them being formed by invagination of the epiblast.

Amphioxus, which so closely resembles an Ascidian in its development, has a perivisceral cavity which essentially corresponds with the atrium of the Ascidian, though it is formed in a somewhat different manner. One of the most striking peculiarities in the structure of Amphioxus is the fact that the body wall (which obviously answers to the somatopleure of one of the higher vertebrata, and incloses a "pleuro-peritoneal" cavity in the walls of which the generative organs are developed), covers the branchial apertures, so that the latter open into the "pleuro-peritoneal" cavity. This occurs in no other vertebrated animal. Kowalevsky has proved that this very exceptional structure results from the development of the somatopleure as a lamina which grows out from the sides of the body and eventually becomes united with its fellow in the middle ventral line, leaving only the so-called "respiratory pore" open. Stieda has mentioned the existence of the rapLè in the position of the line of union in the adult animal. Rathke described two "abdominal canals" in Amphioxus; and Johannes Müller, and more recently Stieda, have described and figured these canals. However, Rathke's canals have no existence, and what have been taken for them are simply passages, or semi-canals, between the proper ventral wall of the abdomen and the incurved edges of two ridges developed at the junction of the ventral with the lateral faces of the body, which extend from behind the abdominal pore where they nearly meet, to the sides of the mouth. Doubtless the ova which Kowalevsky saw pass out of the mouth, had entered into these semi-canals when they left the body by the abdominal pore, and were conveyed by them to the oral region. The ventral integument between the ventrolateral laminæ is folded as Stieda has indicated, into numerous close-set longitudinal plaits which have been mistaken for muscular fibres, and the grooves between these plaits are occupied by epidermic cells, so that in transverse section the interspaces between the plaits have the appearance of glandular cæca. This plaited organ appears to represent the Wolffian duct of the higher Vertebrata, which, in accordance with the generally embryonic character of

Amphioxus, retains its primitive form. The somatopleure of Amphioxus therefore resembles that of ordinary vertebrata in giving rise to a Wolffian duct by invagination of its inner surface. But the Wolffian duct does not become converted into a tube, and its dorsal or axial wall unites with its fellow in the raphé of the ventral boundary of the perivisceral cavity.

In all the higher Vertebrata of which the development has yet been traced, the "pleuro-peritoneal" or perivisceral cavity arises by an apparent splitting of the mesoblast, which splitting, however, does not extend beyond the hinder portion of the branchial region. But in many vertebrata (*e.g.*, Holocephali, Ganoidei, Teleostei, Amphibia) a process of the integument grows out from the region of the hyoidean arch, and forms an operculum covering the gill-cleft. In the frog, as is well known, this opercular membrane is very large, and unites with the body wall posteriorly, leaving only a "respiratory pore" on the left side, during the later periods of the tadpole's life. Here is a structure homologous with the splanchnopleure of Amphioxus; while, in the thoraco-abdominal region, the splanchnopleure appears to arise by splitting of the mesoblast. Considering what takes place in Amphioxus, the question arises whether the "splitting" of the mesoblast in the Vertebrata may not have a different meaning from the apparently similar process in the Arthropoda, Annelida and Mollusca; and whether the pericardium, pleura, and peritoneum are not parts of the epiblast, as the atrial tunic is of the epiblast of the ascidians. Further investigation must determine this point. In the meanwhile, on the assumption that the "pleuro-peritoneal" cavity of the Vertebrata is a virtual involution of the epiblast, the peritoneal aperture of fishes becomes truly homologous with the "respiratory pore" of Amphioxus; and the Wolffian ducts and their prolongations, with the Müllerian ducts, are, as Gegenbaur has already suggested, of the same nature as the segmental organs of worms.

The division of Metazoa without an alimentary cavity is established provisionally, for the Cestoidea and Acanthocephala, in which no trace of a digestive cavity has ever been detected. It is quite possible that the ordinary view that these are Gastrææ modified by parasitism is correct. On the other hand, the cases of the Nematoid worms and of the Trematoda show that the most complete parasitism does not necessarily involve the abortion of the

alimentary cavity, and it must be admitted to be possible that a primitive gregariniform parasite might become multicellular and might develop reproductive and other organs, without finding any advantage in an alimentary canal. A purely objective classification will recognize both these possibilities and leave the question open.

THE SONG OF THE CICADA.

BY F. C. CLARK, M. D.

It must not be considered that all music is a succession of delightful sounds. Harmony, it is true, depends much upon the construction of the musical apparatus, but it depends still more upon the skill of the operator and the taste of the listener. Hence among the lowest insect tribes, many a rough, rasping note, though awakening no particular delight in us, serves as great a purpose as the more pleasant sounds.

On any warm sunny afternoon, or evening, insect courtships take place in countless numbers under our very eyes if we would only use them. What *Katy-did*, which name the insect has borne for ages, still exercises the imagination of poets and philosophers. We hear it loudly whispered in trees and shrubbery, that something was done by "Katy," but beyond that we are left in utter darkness; though some poets have even attempted to unravel the mystery.

Among still higher orders of animals, as our birds, we find the plumage of the male more brilliant, during the pairing season, and their songs more ravishing than before. At this time they charm the human listener, even as much as the delighted female bird. Even our barn-yard cock, good chanticleer, assumes a bolder front, and echoes his joyous notes over hill and dale.

Rising to mammals, man excepted, we shall observe certain sounds more or less pleasant, but still sufficient to fulfil the object for which they were created.

Therefore from the human family, where music reaches its highest perfection, down to the lowest and meanest insect that utters a sound, each furnishes notes to form the grand harmony of nature, in the great struggle for existence. To a cultivated

ear, the peep of a frog, or the chirp of a cricket, is not less unpleasing than the monotonous humdrum of the savage, who represents now the place formerly occupied by the most cultivated nations of the world.

The cicada (or harvest-fly), improperly called "locust," is so familiar that its description seems hardly necessary. Suffice it to say, that from the middle of June to early autumn, this joyous little songster is heard piping away upon the trees.

The insects especially known to us are the trumpeter (*Cicada tibicen*) or lyreman, as it is known in Surinam, from its noise resembling the notes of a lyre, and the red-eyed cicada, or seventeen-year locust (*C. septendecim*). There is a third (*C. canicularis*) which appears during dog-days only. Its inferior aspect is covered with a substance resembling meal.

The lyreman comes to us in a garb of green, and with wings trimmed with the same color. The red-eyed cicada is clothed in red as the lyreman is in green. This last insect has been thought only to appear as its name indicates. But though less numerous than the trumpeter, the red-eyed locusts may be found during every year, though in different regions of our country, its name to the contrary notwithstanding.

But it is the cicada's song, which chiefly interests us now—its "noise" if you will have it so. In some countries where the harvest-fly abounds (for all species of it sing in the same way) its stridulent noise is in some instances almost deafening, and may be heard a mile off. But our cicada, I am happy to say, is not so annoying.

The males alone are provided with the musical apparatus. This fact led a very satirical Greek, Zenarchos by name, to exclaim, I fear, not in a very gallant manner:

> "Are not cicadas truly blest
> By not a female voice oppressed."

The ancients speak of them in the most flattering terms. So much did they please our Greek and Roman friends, that they were kept in cages, as one would pet a bird.

The Athenian ladies wore gold cicadas in their hair as ornaments. A toy cicada, sitting upon a harp, was an emblem of the science of music.

But the cicada was not alone beloved for its song. They were also served up as dainty morsels to Athenian epicures. A shrewd

old philosopher remarked, that cicadas were good in the pupa state, but better when served up full grown, especially the females, just before they have deposited their eggs.

From historians and philosophers we pass to the poets. Their praises and similes here are legion. Homer compares garrulous old men;

"To the cicadas, which infest
The woodlands, and sitting upon the trees
Utter a delicate voice."[1]

And Virgil,

"And shrill cicadæ all the woodland tire" (Southey).[2]

which leaves it apparent to our minds, that their music did not strike our poet as being very melodious.

Since we hear the cicada generally during the hottest part of the day, Virgil says again:

"Under a scorching sun the woods resound
With shrill cicadas' notes."[3]

In fine, no praises seemed too extravagant to lavish upon the harvest-fly. The ancients called them "the love of the Muses," "Sweet prophet of summer," etc. They likened them to the gods. No sound seemed to awaken in their minds memories so pleasant, as the truly delicate voice of the cicada. We can, perhaps, sympathize with them here, when we hear the peeping of the frogs at the opening of spring, the glad token that the long and cold winter is past. Especially can we feel such emotions when we hear them after a long absence from home.

Antipater is said to have preferred the notes of the cicada to the swan's. But all others' praises fall short, compared with what Anacreon bestows upon our little friend. And truly most rapturously he sings

"Oh thou of all creation blest,
Sweet insect! that delight'st to rest
Upon the wild wood's leafy tops,
To drink the dew that morning drops,
And chirp thy song with such a glee,
That happiest kings may envy thee!
Whatever decks the velvet field,
Whate'er the circling seasons yield,
Whatever buds, whatever blows,
For thee it buds, for thee it grows.
Nor yet art thou the peasant's fear,
To him thy friendly notes are dear;
For thou art mild as matin dew,

---

[1] Il. Book III. [2] Geog. III, 328. [3] Bucol. II.

And still, when summer's flowery hue
Begins to paint the bloomy plain,
We hear thy sweet prophetic strain;
Thy sweet prophetic strain we hear,
And bless the notes, and thee revere!
The Muses love thy shrilly tone;
Apollo calls thee all his own;
'Twas he who gave that voice to thee,
'Tis he who tunes thy minstrelsy.
Unworn by ages' dim decline,
The fadeless blooms of youth are thine.
Melodious insect! child of earth!
In wisdom mirthful, wise in mirth:
Exempt from every weak decay,
That withers vulgar minds away;
With not a drop of blood to stain,
The current of thy purer vein,
So blest an age is passed by thee.
Thou seem'st a little deity."[4]

Now after singing the praises of our little friend, the cicada, in not, I hope, too extravagant a vein, we pass to a brief description of his singing apparatus, and learn how he makes his music, and see how wonderful and complicated that organ really is.

Réaumur made numerous dissections of the cicada, and was the first to describe accurately the mode of production of its music. But as these dissections can easily be made, and the insects plenty, each one may investigate quite well for himself. A careful examination of the insect is however necessary, as the whole musical apparatus is within the abdomen in the first ring.

Upon the abdomen of the male, are seen two close fitting scales, rounded at the free end, and straight where they join the body. These can be lifted to a considerable degree, but prevented to too great an extent by two projections which serve to keep the valves (or opercula more properly) in place. Removing the valve, we observe beneath a cell, a little box, so to say, at the bottom of which lies a circular membrane of exceeding thinness, and presenting all the colors of the rainbow. Réaumur calls it the mirror. It resembles the drum of the ear, and affords much pleasure even in a cursory examination. Imagine for the time two cells, with each a window opening into the internal parts of the body, and concealing machinery which works the apparatus. Each cell is divided into three parts by a triangular plate; the upper boundary being a semilunar membrane, which may be con-

[4] Ode XXXIV, Moore's Trans.

tracted or relaxed at the pleasure of the insect, and the part containing the mirror. But the real organ is only seen from the back. It is found a little below the external covering of the animal, directly facing the membranous drumhead in the first cavity. It consists of a very thin membrane, wrinkled, and can be moved back and forth within its circumference, causing a snapping noise, something like the sounds given out by the live insect. Attached beneath each drumhead are fibres of muscle, which join near the inside edge of the mirrors, and form one, which is inserted to the back. If we pull one, or both these muscles, the well known sound is emitted. When these muscles are contracted or pulled, the drumhead falls in; and when relaxed, the drumhead springs into position by its own elasticity. We can therefore imagine how, when these muscles are contracted with sufficient rapidity, the insect sings his song. The musical instrument is therefore, simply a little drum. The sound passes through the first cell, and its pitch is regulated by the movable semilunar membrane. Then striking against the mirror the sound may be reinforced; and then passes out by the valves which regulate its intensity in some manner. For on pressing the valves closely to the body, little sound, if any, is emitted; raise up the valves as high as possible and the sound is most intense.

The insect may be kept captive for some time, and in this condition much may be learned from actual observation. Boys in Surinam fasten straws to the cicadas and run with them through the streets. Its "noise" has been compared to the sound given out by whirling a piece of cardboard attached to a string, rapidly through the air.

The cicada, though as in the seventeen-year species maturing for several years, lives but for a brief season. With the expiring summer he takes his leave, and testifies with his lingering life, a glad song which grows feebler and feebler, till finally it dies away sadly but beautiful like the summer he carries with him.

ON THE BREEDING OF CERTAIN BIRDS.

BY DR. ELLIOTT COUES, U. S. A.

No. 2.

In the treeless portions of Montana, the streams that meander through the boundless prairies constantly present the feature of "cut-banks," which I mentioned in my last article as the breeding resort of various hawks. This furnishes other exceptional instances of terrestrial nidification, which may well be placed on record.

Probably no birds vary more in their modes of nesting according to different circumstances than swallows; and certainly none adapt themselves more readily to their surroundings. On the face of the cut-banks, as would be expected, thousands of cliff swallows fasten their bottle-shaped nests of mud; but who would have anticipated the breeding amongst them of barn swallows, in holes in the ground? In various parts of Montana, where there were no trees, and no breaks in the prairie excepting the "coulés" (ravines) and streams, I frequently saw troops of barn-swallows, and for some time wondered where they bred. At length Mr. Batty, one of my assistants, found some nests of this species, and settled the question. The nests were placed in little excavations on the face of the banks, deep enough to be fairly called "holes," and answering all the purpose of the corner of the rafters, which the bird usually selects. Mr. Batty surmised that in some instances at least, the bird enlarged and adapted, if it did not actually dig out, the excavation; but of this I do not feel sure. It seems more probable that choice was made of the natural indentations of the bank, just as was the case with the hawks already mentioned.

At one of our camps on a small tributary of Milk River, on the boundary line of the United States and British America, two nests of the golden eagle (*Aquila chrysaëtes*) were found within a mile of each other, each capping a piece of cut-bank.

Viewed from the prairie side they seemed, and actually were, to all intents and purposes, placed on the bare level ground; from the reverse aspect the natural instinct of nesting on a crag was

seen to be fulfilled. But one would think that if an eagle were to stoop to nest in such a place, the bird would choose the highest and boldest embankment in the vicinity. Such was not, however, the case. One of the nests which I visited was rather upon the brow of a little hill than the edge of a cliff. The distance from the bed of the stream was no more than an easy gunshot, and the inclination was so slight that I readily walked up the embankment, gun in hand. The nest was composed of sticks, some of which were as large as one's wrist, brushwood and bunches of grass and weeds with masses of earth still adhering to the roots. It was about four feet across in one direction, and three in the other, the shape being suited to the slight projection of ground on which the nest rested; the matted mass of material averaged about six inches deep. The other nest was described to me as considerably larger. Both were empty and apparently deserted. Although I saw no eagles just at this spot, I do not hesitate to identify the nests as those of the species mentioned, for the birds were very frequently — almost every day — seen in the neighboring Sweetgrass Hills. There do not appear to be any bald eagles in the country, and the nests were altogether too large to have been those of any kind of hawk known to occur in the region.

Some years ago, Dr. F. V. Hayden brought us from the mountains a pair of harlequin ducks (*Histrionicus torquatus*), and accompanying the specimens was an egg cut from one of them. This fact, coupled with the date of capture (May 31), led to the inference of the breeding of this species in the Rocky Mountains within the limits of the United States. The past season (1874) I have had the pleasure of establishing the fact. At Chief Mountain Lake, near the heart of the Rockies, where the U. S. Boundary line crosses, I found broods of young harlequins still unable to fly, late in August. Several specimens, including the mother of one of the broods, were secured; the adult male was not observed. What is somewhat unusual for ducks, this brood was found in a clear ice-cold mountain torrent, disporting in a pool at the foot of a cascade. The altitude was about five thousand feet. The character of the stream may be clearly recognized in the fact that it was full of beautiful trout of two species, and was also the home of the water ouzel (*Cinclus Mexicanus*). When disturbed, the old bird flew low over the water, while others sank back quietly into the limpid element, till only the head remained above the

surface — just like grebes; some sought refuge behind and beneath the cascade, screened by the whole volume of water that leaped over the projecting rocks. Another brood was seen swimming quietly in one of the side pools near the lake.

With the harlequins was also breeding a species of *Bucephala*. It was not *B. albeola*, but whether *B. clangula* or *B. islandica* is yet undetermined, as I did not take the old male, and as the young ones cannot be determined without comparison of specimens that I cannot make in the field.

The breeding of the Bohemian waxwing (*Ampelis garrulus*) long remained unknown, and to this day my only records of its nesting on this continent have come from Alaska, whence specimens of the eggs were lately brought. It is a matter of satisfaction to be able to attest its breeding in the Rocky Mountains, on, or at any rate very near, the border of the United States. On the 19th of August, while I was at Chief Mountain Lake (this beautiful sheet of water lies across our line), a Bohemian waxwing was shot by my assistant, Mr. A. B. Chapin, who picked it out of a flock of common cedar birds. It was still in the peculiar streaky stage of plumage which is characteristic of the very young bird, and must have been hatched somewhere in the vicinity. Additional evidence in favor of this induction lies in the fact that the cedar birds were breeding at the same time. Several young ones were shot, and Mr. Chapin secured a nest containing four partially incubated eggs. This was late (Aug. 19) even for so tardy a breeder as the cedar bird is well known to be. But the birds were in mountains, and at a latitude (49°) north of their average breeding range. What with the rare ducks just mentioned, the water ouzels, dusky grouse, and the curious little chief hare, *Lagomys princeps*, to say nothing of the aristocratic Bohemians, our familiar friends were here in very select company.

There are some interesting points, all of which may not be generally known, respecting the range of the flickers in this part of the world. In the Red River Valley, and clear away westward on the parallel of 49° to where the Coteau of the Missouri crosses this line, you get nothing but pure *auratus*. I have shot this nearly to the head waters of the Souris or Mouse River. Throughout the greater part of the Missouri region proper — the immense extent of which must be travelled over to be thoroughly appreciated — the curious "hybrid" form prevails. I never saw a speci-

men that did not show the mixture of *Mexicanus*, from any part of the Missouri water-shed beyond the strict limits of the Eastern Province. But at the Rocky Mountains this mongrel breed runs up north into the Saskatchewan region at least, if not farther. In latitude this is more than abreast of the Mouse River area where *auratus* flourishes untouched with red. I have specimens of various grades of "hybridity" from the mountains where the St. Mary's, the Kootenay (or Kootanie) the Belly and other tributaries of the northern waters arise.

Audubon's warbler (*Dendrœca Auduboni*) breeds in the Rocky Mountains at the locality lately specified. Several very young birds were shot in August.

There is something I have not quite made out respecting the breeding range of Sprague's lark, *Neocorys Spraguei*. The bird can hardly be more abundant anywhere than it is in the country west of the Red River and north of the Missouri Coteau. I certainly saw several thousand last year. The present season, at the site of Fort Union (Audubon's original locality), and thence up the Missouri to the mouth of Milk River, I noticed altogether a few hundred perhaps. But the birds were not common, and in all the country west of this I saw none at all until I came upon the head of Milk River, just at the ridge that divides these waters from those of the Saskatchewan. There, among the foothills of the Rockies, the species reappeared. Much the same peculiarity attaches to the breeding range of Baird's bunting. This bird is everywhere over the Mouse River region, and the type came from the Upper Missouri, but during the summer just passed I have failed to find a single one in the whole country from the mouth of the Yellowstone to the headwaters of the Saskatchewan.—*Fort Benton*, *Montana*, *Sept.* 9, 1874.

THE COLOSSAL CEPHALOPODS OF THE NORTH ATLANTIC. II.

BY PROF. A. E. VERRILL.

After the first part of this article was printed, I received an interesting letter from the Rev. Mr. Harvey, who, in accordance with my request, has made a new examination of the large arm of

"No 2," preserved in the Museum at St. John's, N. F. He states, in this letter, that all the suckers were originally denticulated around the margin, as suggested by me in the last number of the NATURALIST, and that this fact was previously overlooked on account of the mutilation it had undergone. He has also furnished to me a full series of measurements of its various parts. It has contracted excessively in the alcohol, and is now only thirteen feet and one inch in length (instead of nineteen feet, its original length), the enlarged sucker-bearing portion being two feet and three inches; the large suckers occupy twelve inches; the terminal part bearing small suckers, nine inches; circumference of slender portion 3·5 to 4·25 inches; of largest part 6 inches; breadth of face, among large suckers, 2·5 inches; from face to back, 1·62 inches; diameter of largest suckers outside, ·75 of an inch; inside, ·63 of an inch. It will be evident from these measurements, when compared with those made while fresh and from the photograph, that the shrinkage has been chiefly in length, the thickness remaining about the same, but the suckers are considerably smaller than the dimensions previously given.

Mr. Harvey also mentions that a specimen was cast ashore at Bonavista Bay, December, 1872, and his informant says that the long arms measured thirty-two feet in length, and the short arms about ten feet in length, and were "thicker than a man's thigh." The body was not measured, but he thinks it was about fourteen feet long, and very stout, and that the largest suckers were 2·5 inches in diameter. The size of the suckers is probably exaggerated, and most likely the length of the body also. It is even possible that this was the same specimen from which the beak and suckers described in my last article, as No. 4, from Bonavista Bay, were derived, for the date of capture of that specimen is unknown to me. The latter, however, was much smaller than the above measurements of the former would admit, and it will, therefore, be desirable to give this one a special number (11).

Another specimen, which we may designate as No. 12, was cast ashore this winter, near Harbor Grace, but was destroyed before its value became known, and no measurements are given.

Architeuthis princeps Verrill, sp. nov., figures 25, 26, 27. This species is based on the lower jaw mentioned as No 1 in my former papers, and on the upper and lower jaws designated as No. 10, in the first part of this article; besides these jaws we only have the

rough measurements of the body of No. 4, and an estimate of the diameter of the sessile arms. The jaws of No. 10 were obtained from the stomach of a sperm whale taken in the N. Atlantic, and were presented to the Essex Institute by Capt. N. E. Atwood, of Provincetown, Mass., but the date and precise locality of the cap-

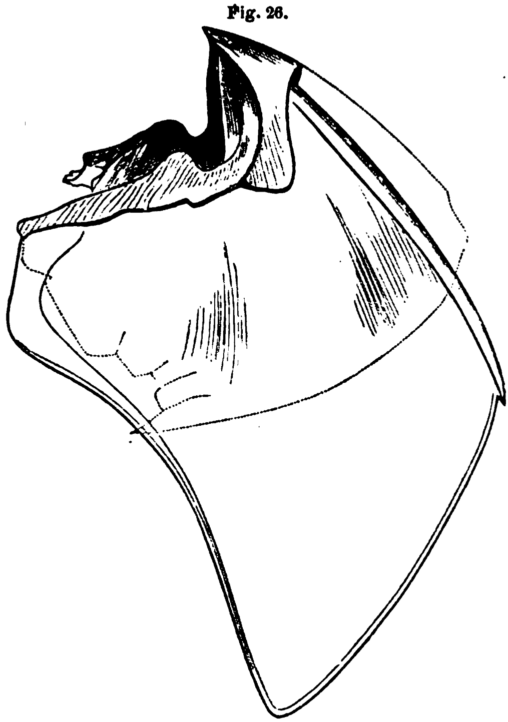
Fig. 25.

Upper jaw of Architeuthis princeps Verrill. No. 10. Natural size.

ture are unknown. The form of these jaws is well shown in figures 25 and 26. The total length of the upper jaw (fig. 25) is 5 inches; greatest breadth, 1·45; front to back 3·5 inches; width of palatine lamina, 2·32. The frontal portion is considerably broken, but the dorsal portion appears to extend nearly to the

posterior end, the length from the point of the beak to the posterior edge being 3·4 inches. The texture is firmer and the lamina are relatively thicker than in *A. monachus*. The rostrum and most of the frontal regions are black and polished, gradually becoming orange-brown and translucent toward the posterior border, and marked with faint striæ radiating from the tip of the beak, and

Fig. 26.



Lower jaw of Architeuthis princeps. No. 10. Natural size. The dotted line shows the portions that are present on the back side.

by faint ridges or lines of growth parallel with the posterior margin; a slight but sharp ridge extends backward from the notch at the base of the cutting edge, and other less marked ones from the anterior border of the alæ. The tip of the beak is quite strongly curved forward, and acute, with a slight shallow groove, commencing just below the tip, on each side, and extending backward only a short distance and gradually fading out. The cutting edge is nearly smooth and well curved, the curvature being greatest toward the tip; at its base there is a broad angular notch, deepest

externally. The inner face of the rostrum is convex in the middle and concave or excavated toward the margins, which are, therefore, rather sharp. The anterior borders of the alæ are convex, or rise into a broad, but low, lobe or tooth beyond the notch, but beyond this they are nearly straight, but with slight, irregular lobes, which do not correspond on the two sides. The anterior edges of the alæ make nearly a right angle with the cutting edges of the rostrum. The palatine lamina is broad, thin, and dark brown, becoming reddish brown and translucent posteriorly, with a thin, whitish border. The surface is marked with unequal divergent striæ and ridges, some of which, especially near the dorsal part, are quite prominent and irregular; the posterior border has a broad emargination in the middle. but the two sides do not exactly correspond. The lower jaw (fig. 26) was badly broken, and many of the pieces, especially of the alæ, are lost, but all that remain have been fitted together. The extreme length is 3·63 inches; the total breadth, and the distance from front to back, cannot be ascertained, owing to the absence of the more prominent parts of the alæ; from tip of beak to posterior dorsal border of mentum, 1·68; from tip of beak to posterior lateral border of alæ, 2·20; from tip of beak to posterior dorsal border of gular lamina, 2·37; from tip of beak to bottom of notch at its base, ·80; tip of beak to inner angle of gular lamina, 1·85; height of tooth from bottom of notch, ·25; breadth between teeth of opposite sides, ·60; from front to back of gular lamina, in middle, 1·75. The rostrum is black, with faint radiating striæ, and with slight undulations parallel with the posterior border; the beak is acute, slightly incurved, with a notch near the tip, from which a very evident groove runs back for a short distance, while a well marked, angular ridge starts from just below the notch, and descends in a curve to the ala, opposite the large tooth, defining a roughened or slightly corrugated and decidedly excavated area, between it and the cutting edges; the cutting edge below this ridge is nearly straight, or slightly convex; the notch at its base is rounded and deep and strongly excavated at bottom; the tooth is broad, stout, obtusely rounded at summit, sloping abruptly on the side of the notch, and gradually to the alar edge. The anterior edge of the alæ, beyond the tooth, is rounded and strongly obliquely striated: it makes, with the cutting edge, an angle of about 110°. The inner surfaces of the two sides of the internal plate of the rostrum form an angle of about 45°.

The lower jaw of No. 1 (fig. 27) is represented only by its anterior part, the alæ and gular laminæ having been cut away by the person who removed it. It agrees very well in form and color with the corresponding parts of the one just described, but is somewhat smaller. The lateral ridges of the rostrum are rather more prominent, and the area within it is narrower and more deeply excavated, especially at the base of the notch, where the excavation goes considerably lower than the inner margin. The notch is narrower and not so much rounded at its bottom. The tooth is about the same in size as that of No. 10, and appears to be even more prominent, because the edge of the alæ is more concave at its outer base; it is also more compressed and less regularly rounded at summit; the anterior edge of the alæ seems to rise into another low lobe beyond the concave portion. This jaw measures 1·30 inches from the tip to the posterior dorsal border of mentum; ·65 from tip to the bottom of the notch; ·16 from bottom of notch to tip of the tooth.

Fig. 27.

Part of lower jaw of Architeuthis princeps. No. 1. Nat. size.

Both these lower jaws agree in having a very prominent tooth on the alar edge, with a large and deeply excavated notch between it and the cutting edge, and in this respect differ from the two lower jaws of *A. monachus* in my possession, for in the latter the tooth or lobe is low and broad, and scarcely prominent, while the notch is narrow and shallow. This seems to be the best character for distinguishing the jaws of the two species. But they also differ in the angle between the alar edge and the cutting edge of the rostrum, especially of the lower jaw, for while in *A. monachus* this is hardly more than a right angle, in *A. princeps* it is about 110°. Moreover, the darker color and firmer texture of the jaws of the latter seem to be characteristic.

The proportions of the body seem to be quite different, if we can judge by the measurements given of the specimen (No. 1) which was found dead and floating at the surface of the water, at the Banks of Newfoundland, by Capt. Campbell, of the schooner

B. D. Haskins, from Gloucester, Mass., in October, 1871.[1] It is stated that this specimen was measured, and that the body was fifteen feet long, and four feet and eight inches in circumference. The arms were badly mutilated, but the portions remaining were estimated to be nine or ten feet long and about twenty-two inches in circumference, two being shorter than the others. This would indicate a much more elongated form of body than that of *A. monachus*. If these proportions be correct, the body of No. 10 must have been about nineteen feet in length, and five feet and nine inches in circumference.

This specimen is probably the largest invertebrate hitherto actually examined by any naturalist. Larger cephalopods may possibly have been seen by mariners, but most of their statements of size are only rude estimates, and are nearly always much exaggerated.

Notes on specimens described by other writers. We are mainly indebted to Professor Steenstrup and to Dr. Harting for our knowledge of the specimens preserved in European museums, or cast ashore on the European coasts. Professor Steenstrup has given interesting accounts, compiled from contemporary documents, of a specimen taken in 1546, and of two specimens of huge cephalopods cast ashore at Iceland in 1639 and 1790, and has also described and figured[2] the jaws of another specimen o *A. monachus*, obtained at Jutland in 1853. In the same memoir, of which I have seen only the first part, there are references to a description and figures of *A. Titan*, obtained in 1855, by Capt. Hygom, in N. Lat. 31°; W. Long. 76.° The latter specimen appears to be the same that Harting[3] mentioned under the name of "*Architeuthis dux* Steenstrup," as collected at the same time and place, and of which he published an outline figure of the lower jaw, copied from a drawing furnished to him by Steenstrup. Harting states that the pen or "gladius" of this specimen is six feet long. Many important parts of this specimen were secured, and I

[1] See the American Naturalist, Vol. vii, p. 91, Feb., 1873.

[2] In a paper, of which I have only seen some proof-sheets, given by him to Dr. Packard, entitled "Spolia Atlantica." Whether this memoir has been published I do not know. The plate (J) that I have seen, is marked "Vid. Selsk. Skrifter V. Række, naturv. og mathem. Afd. iv, Bind;" and there are references to three other plates illustrating *A. Titan*, etc.

[3] Description de quelques fragments de deux Céphalopodes gigantesques. Publiées par l' Académie Royale des Sciences à Amsterdam. 1860. 4to, with three plates.

regret that I have been unable to see the figures and description of it, referred to by Harting as forming part of Prof. Steenstrup's memoir, then unpublished. But to judge by the outline figure given by Harting, it is a species quite distinct from those described above. The lower jaw resembles that of *A. monachus* more than *A. princeps*, and is a little larger than that of our No. 5 (see fig. 6). The beak is more rounded dorsally, less acute, and scarcely incurved, the notch is narrow, and the alar tooth is not prominent.

Harting, in the important memoir referred to, describes specimens of two species, both of which are evidently quite distinct from all those enumerated above.

The first of these (Plate I) is represented by the jaws and buccal mass, with the lingual dentition, and some detached suckers, preserved in the museum of the University of Utrecht, but from an unknown locality. These parts are well figured and described, and were referred to *Architeuthis dux* by Harting. But the character of the dentition (fig. 28) is so totally different from

Fig. 28.

Teeth of Loligo Hartingii Verrill. Enlarged.

what I have found in *A. monachus* that it will be necessary to refer this species to a different genus, if not to a distinct family. The form of the lower jaw is quite unlike that of *A. dux*, for the beak is very acute, the cutting edge is concave, the notch shallow and broad, and the alar tooth is somewhat prominent. The size is about the same as our No. 5. The suckers figured are from the sessile arms, and agree pretty nearly with those of *A. monachus* (see fig. 3). The edge is strengthened by an oblique, strongly denticulated ring. The internal diameter of the largest of these suckers is ·75 of an inch; the external, 1·05 inches. They were furnished with slender pedicels, attached obliquely on one side. The lingual teeth (see fig. 28 copied from Harting,) are in seven regular rows, and resemble closely those of *Loligo* (fig. 9). In fact, I cannot find, in the figures and description, any character by which this species can be separated from *Loligo*, and at the same time it is evident that it is a species distinct from all others

known. I would, therefore, propose to designate it by the name of *Loligo Hartingii*.

The other species described by Harting was represented by the jaws and pharynx, an eye, a part of one of the sessile arms, and of one of the long tentacular arms, preserved in the museum of the Zoological Garden of Amsterdam. They were taken from the stomach of a shark, captured in the Indian Ocean. Harting referred this specimen to the genus *Enoploteuthis*, and doubtfully to the species described by Owen under the name of *E. unguiculata*, from a specimen in the Hunterian museum, collected between Cape Horn and Australia by Banks and Solander, on Capt. Cook's first voyage. The jaws of this species are very sharp and strongly incurved, and a little smaller than those of the *Loligo Hartingii*. Instead of circular suckers with denticulated margins, the arms bear two rows of large sharp incurved hooks or claws, arising from large, swollen, muscular bulb-like bases, attached to the arms by short pedicels. The lingual dentition is also quite peculiar, but the teeth are arranged in seven rows, as usual.

Mr. Kent, in the article already referred to,[4] mentions a sessile arm of a giant cephalopod, which has been long preserved in the British Museum, but of which the origin is unknown. He states that it is 9 feet long; 11 inches in circumference at the base, tapering off to a fine point. There are from 145 to 150 suckers, in two alternating rows, those at the base being half an inch in diameter. The relatively small size of the suckers and great length of the arms show that this arm cannot belong to the same species as our *Architeuthis monachus*, which Mr. Kent thought probable. But as the arms of *A. princeps* and *Loligo Hartingii* are still unknown, it may belong to one of those species, or it may belong to the species observed, but not captured, by the officers of the "Alecton," in 1861, near Teneriffe, and named *Loligo Bouyeri* by Crosse and Fischer, but known only from the imperfect descriptions of it given by the officers, and a sketch of it prepared while the crew were making unsuccessful attempts to get it on board.

The body of this one was estimated at 15 to 18 feet in length, with the arms somewhat shorter.

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[4] Proceedings Zoological Society of London, for 1874, page 178.

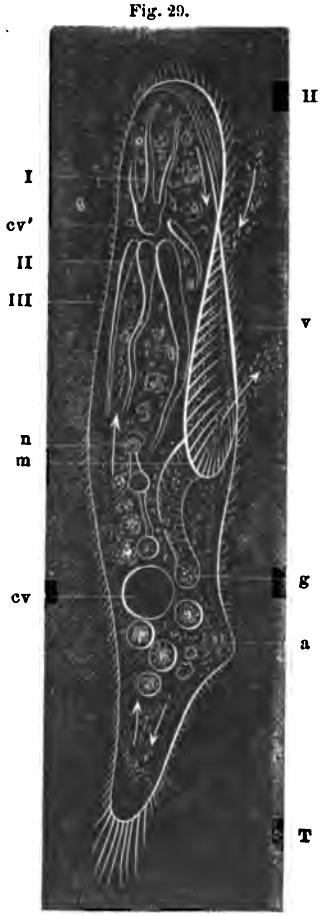
LIFE HISTORIES OF THE PROTOZOA AND SPONGES.

BY A. S. PACKARD, JR.

VII. THE INFUSORIA (CILIATA).

Though the term Infusoria has usually been applied to nearly all the Protozoa provided with cilia or flagella, it is now restricted to the highest division of the Protozoa. Instead of an attempt to define the group, the following brief description of some of the well-known forms will perhaps best show how they differ from the Flagellata, with which they are most apt to be confounded.

Fig. 29.



Paramecium.

One of the simplest and most abundant forms is Paramecium. The accompanying figure (29), copied from Clark's "Mind in Nature," represents *Paramecium caudatum*, of Ehrenberg.[1] This animalcule is a mass of protoplasm, representing, perhaps, a cell. In the body-mass are excavated a mouth and a throat leading to a so-called stomach or digestive cavity. Two hollows in the body form the contractile vesicles, and another cavity forms the reproductive organ. Prolongations of the body-mass form the cilia, which characterize the Infusoria and give their name, Ciliata. No specialized tissues composed of cells exist in these organisms, and they are regarded as on the whole representing a single cell. Some authors, as Claparède, regard them as composed of several cells, but the whole animal, though performing functions nearly

[1] Fig. 29. A view from the dorsal side, magnified 240 diameters. H, the head: T. the tail; *m*, the mouth; *m* to *g*, the throat; *a*, the posterior opening of the digestive cavity;

as complicated as those of sponges, low worms and radiates which have bodies composed of many cells, should be regarded as made up of indifferent or unorganized sarcode or protoplasm, somewhat like that of the bodies of the embryos of the higher animals in their earliest stages.

Paramecium has an elongated, oval body "with one end (H) flattened out broader than the other, and twisted about one-third way round, so that the flattened part resembles a very long figure 8." In this form, as in Stentor (Fig. 30), as Clark remarks, "we have the mouth at the bottom of a broad notch or incurvation, and the contractile vesicle on the opposite side, next the convex back, whilst the general cavity of the body lies between these two." The arrows in the figure represent the course of the particles of indigo with which Clark fed his specimens, "as they are whirled along, by the large vibrating cilia (*v*) of the edge of the disk, against the vestibule of the mouth." During the circuit the food is digested, a mass of *rejectamenta* is formed near the protuberance, *a*, which has appeared a short time before. This finally opens, allows the rejected matter to pass out and then closes over, leaving no trace of an outlet. This and other Infusoria seem, then, to have a definite digestive tract, hollowed out of the parenchyma of the body.

"The system," says Clark, "which is analogous to the blood circulation of the higher animals, is represented in Paramecium by two contractile vesicles (cv, cv^1, I, II, III), both of which have a degree of complication which, perhaps, exceeds that of any other similar organ" in these animals. When fully expanded they appear round, as at *cv;* but when contracted they appear, observes Clark, as "fine radiating streaks, and as the main portion lessens they gradually broaden and swell until the former is emptied and nearly invisible, and they are extended over half the length of the body. In this condition they might be compared to the arterial vessels of the more elevated classes of animals, but they would at the same time represent the veins, since they serve at the next moment to return the fluid to the main reservoir again, which is effected in this very remarkable way." The contents of these vesicles is a clear fluid.

The reproductive organ in Paramecium is a small tube (*n*), only seen at the reproductive period when the eggs (*n*) are fully grown.

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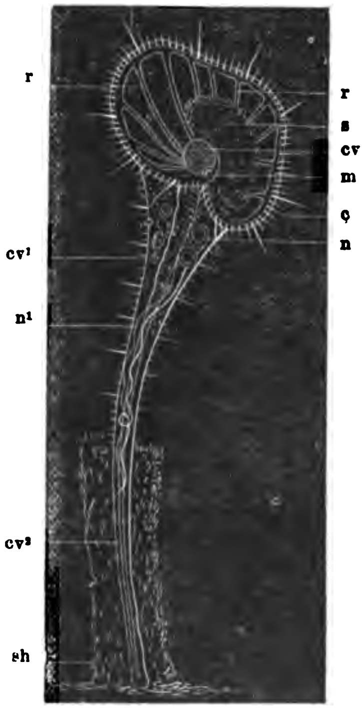
cv^1, the anterior and *cv*. posterior contractile vesicles; I, II, III, the radiating canals of cv^1; *n*, the reproductive organ; *v*, the large vibrating cilia at the edge of the vestibule. —After H. J. Clark.

Clark says that the eggs are arranged in it "in a single line, one after the other, at varying distances." It usually lies in the midst of the body, and extends from one-half to two-thirds of the length of the animal. "According to Balbiani's observations upon a closely allied species, when the eggs are laid they pass out from the ovary through an aperture near the mouth" (Clark).

Fig. 30.



Trumpet Animalcule.

In the Trumpet animalcule (Fig. 30, *Stentor polymorphus* of Ehrenberg, after Clark[2]) we have a higher grade of development than in Paramecium, the animalcule attaching itself at one end, and building up a slight tube in which it contracts when disturbed; an anticipation in nature of the worm in its tube. Prof. Clark has studied in this animalcule certain circular bands within the edge of the disk, from which arise twelve very thin stripes (*rr*) which converge towards the mouth (*m*). These bands are evidently, he says, in close relation with the mouth and cilia, the most active organs of the animal, and he concludes that it is a nervous system.

The most complicated form of all among the Infusoria is the Vorticella, or bell-shaped animalcule. These forms are very common on submerged plants and leaves, appearing to the naked eye like mould. Their motions, as they suddenly contract and then

[2] "*Stentor polymorphus*, magnified 130 diameters, expanded and bent slightly over towards the observer; the mouth, *m*, next the eye, and the dorsal edge in the distance. *a*, posterior end; *sh*, the tube enclosing *a*; *c*, the ciliated border of the disk (*s*); *b*, the larger, rigid cilia; *cv*, the contractile vesicle in the extreme distance. seen through the whole thickness of the body; *cv*¹, *cv*², the posterior prolongation of *cv*, in the distance; *r*, *r*¹, the circular and radiating branches of the nervous system; *n*. *n*¹, the reproductive system, extending from the right side, at *n*, posteriorly, but towards the eye at *n*¹ (Clark).

shoot out their bell, mounted on a long stalk, are very interesting. They form the most available and attractive infusoria for study and amusement. The throat is quite distinct, while the nucleus is the most conspicuous organ of the body. The digestive cavity is "one vast hollow," in which the whole mass of food revolves in a determinate channel (Clark). In fact, so highly developed are these Infusoria that they seem to anticipate certain low worms to which they bear a certain resemblance, and indicate that the worms may have sprung either from the Infusoria or early organisms like them.

Fig. 31.

Fig. 32.

Bell-shaped Animalcule, natural size; and one enlarged.[3]

Bütschli claims to have discovered that lasso cells like those in the Hydra and jelly fishes are developed in a certain infusorium named by him Polykrikos.

The Infusoria may be divided into three groups; 1, represented by Paramecium; 2, by Vaginicola and Vorticella, and 3, by Acineta (Fig. 33, H). This latter form is not ciliated, the body is stalked and in front prolonged into slender suckers, each terminating in a mouth. At one time Stein supposed that the Vaginicola or Vorticella passed into an "Acineta-form," but Claparède disproved this and Stein retracted his opinion.

Development. The different modes of development among the Infusoria are still involved in doubt. The best observers have advanced theories that have appeared sound, and then revoked them. All agree, however, that the simplest and commonest mode of development is fission, a process analogous to the ordinary

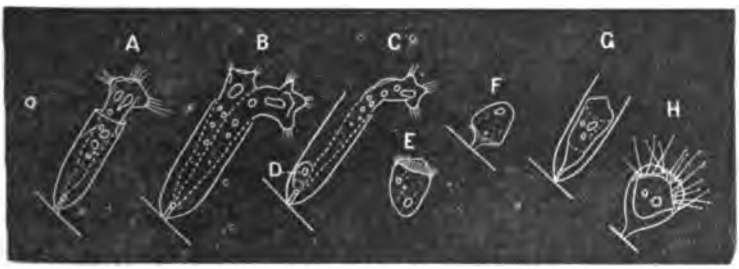
[3] Fig. 31 "*Epistylis flavicans* Ehr., a single, many-forked colony of bell animalcules, slightly magnified. Fig. 32, one of the animalcules magnified 250 diameters. *p*, the stem; *d*, the flat spiral of vibrating cilia at the edge of the disk; *ms*, the muscle; *m* to *s*, the depth of the digestive cavity; *m*, the mouth, *g*, g^1, the throat; *l*, the single vibratory lash, which projects from the depths of the throat; *cv*, the contractile vesicle: *n*, the reproductive organ" (Clark).

self-division of the nucleus of eggs, and the primary mode of growth in both animals and plants, not involving the idea of sex.

As a good example of *fission*, by which all Infusoria are supposed to multiply their kind, though some may at certain times reproduce from eggs, we may cite a case observed by Clark, the full account of which is given in his admirable "Mind in Nature." He observed a *Stentor polymorphus* divide in two. The first change taking place is in the contractile vesicle, which divides into two distinct vesicles. The mouth of the new Stentor is formed in the middle of the under side, first appearing as a shallow pit, around which arises a semicircle of vibratile cilia. The new mouth deepens, the throat is hollowed out; all this taking place before any external sign of division appears. But in the course of two hours the body splits asunder, and two new individuals appear, each exactly like the other.

In Vaginicola there is a modification of this simple process, which is more like true gemmation or budding, and is accompanied by a process of encysting. Our figures of the mode of development

Fig. 33.



Development of Vaginicola.

are taken from a short paper by C. J. Müller. He first traced the fission of this infusorium (Fig. 32, A), which takes place in the following manner. After the animal has withdrawn within its case, and assumed a pear-shaped form, its cilia, meanwhile, apparently lost, a conical fissure appears at the base, and soon after "a wavy line of division shows itself at the upper extremity of the animalcule;" the two fissures enlarge and meet; pulsating vesicles become active on both sides of the line of fission, and cilia begin to grow out, until at the end of an hour, two separate animals are formed, which soon afterwards appear as in Fig. 33, B.

Now begins a new process; the production of a free swimming embryo. On one of the two Vaginicolas is developed "a delicate ring or band at about one-third its length from the lower extremity." Then it contracts in its cell, becomes quiet (as in Fig. 33, C, D) and from the ring or band develops a new circle of cilia, the former ones having disappeared. It then swims off as at Fig. 33, E, darting about rapidly until it attaches itself to a piece of Conferva, as at Fig. 33, F. After some hours, perhaps twenty, a fringe of cilia begins to appear on the upper end, the old ones begin to be absorbed, and the tube arises, as at Fig. 33, G, and a new Vaginicola appears. Stein had some years previous made similar observations on *Vaginicola crystallina* Ehr., and thought he had traced their further development into a form resembling Acineta (Fig. 33, H), but this proved afterwards to be a young parasitic Acineta, a suctorial Infusorian.

We have seen that Vaginicola passes through a resting stage, withdrawing into the case in which it lives, and being for a time inactive. Stein has shown that all the Vorticellinæ "at an earlier or later stage of their development become encysted, by drawing in their ciliated disk and contracting their bodies into a ball; at the same time secreting around themselves a gelatinous mass which solidifies into a firmer elastic covering." Fig. 34, G, after Stein, shows a Vorticella thus encysted. After becoming thus encysted the interior becomes homogeneous, as in Fig. 34, H. From this cyst the Vorticellæ arise directly.

Now a second mode of development, and the simplest, has been observed by Stein, *i. e.*, that of monad-like young which result from the breaking up of the cyst. While examining a cyst Stein observed that it burst, and the free contents "remained as a round, transparent limpid drop of jelly, of about the same diameter as the cyst, in which some thirty embryos, of the form of *Monas colpoda* or *Monas scintillans*, sailed about with varied and active motion, as if in a little ocean." These embryos resulted from the breaking up of the band-like nucleus. This breaking up did not take place "by successive acts of division, but in the nucleus, round disks become marked off contemporaneously, at the most distant points; whilst the intermediate substance of the nucleus becomes re-absorbed."

It thus seems that the Ciliata pass through a flagellate or monad condition. Stein regards the above described propagation by the

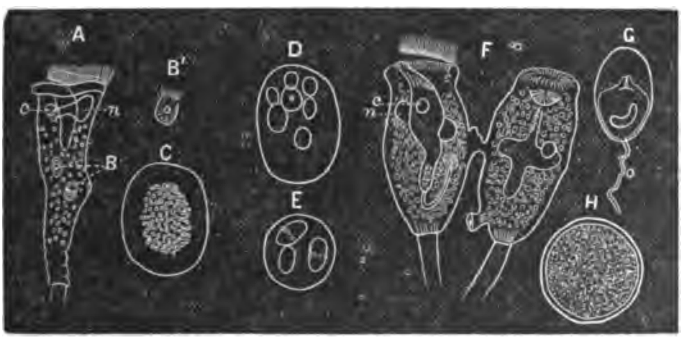
change of the whole inner encysted body of a Vorticella into numerous embryos, as the equivalent of the sexual propagation of the higher animals. We also quote Stein's summary of the cycle of changes undergone by the Vorticella: "We may thus ideally arrange the different stages of development through which the *Vorticellæ* pass; the largest end their lives by becoming encysted; the whole of the contents of their bodies then passes into embryos, to which the dividing germ-nucleus first gives origin.

"The embryos become fixed, develop from their posterior extremity a stalk, which is at first not contractile, and gradually change their monad-like bodies into that of a common Vorticella.

"As soon as this has taken place, their very much smaller size only distinguishes them from the perfect Vorticellæ. Even in this imperfect condition they frequently multiply by continual division and in a subordinate degree by external gemmation. This power of multiplication in the imperfect state, however, is one of the most certain criteria that we have to do with an alternation of generations. * * * * Finally, the last generation become encysted, not to re-awake to an independent existence, but to break up into a swarm of embryos."

Let us now look at the development of *Epistylis plicatilis* as studied by Claparède. Fig. 34, A, represents an individual con-

Fig. 34.



Development of Epistylis.

taining several embryos (B) and opposite the lower one on the right side is a projection, through which the embryo at B′ has passed out. The specimen figured at B′ is a fair example of the embryos of species belonging to six families of Infusoria, and

may, perhaps, serve as a typical example of most Infusoria at the time of birth. This young stage may, then, be contrasted with the embryos of the Flagellata, which are of a much simpler form, resembling the zoospores of the algæ and lower Protozoa.

The embryos of the Infusoria arise from the nucleus, which corresponds to the ovary of the higher animals. The nucleus is a curved, oblong, oval body, represented in Figs. 34, A, *n*; 35, E. When the Epistylis is about to reproduce its young, the nucleus sends off a portion which enlarges until it assumes the appearance indicated by Fig. 34, C. It has become round, and contains a central, granular mass, from which the embryos arise. At Fig. 34, D, is a globular mass, detached from the nucleus, and containing several embryos in the first state of development. Fig. 34, E, represents the embryos provided with a circle of cilia, and nearly ready to swim about freely. Claparède did not watch their farther development, but thought it probable that they grew directly into the Epistylis form.

What is the meaning of conjugation in the Infusoria is not clearly understood. Whether it is analogous to sexual union is not certainly known, but it is now thought by Balbiani that the smaller individuals found conjugating with the larger are males, and he even thinks that some Infusoria contain spermatozoa. Fig. 34 represents an Epistylis conjugating, each one provided with two buds; the bud of the individual on the left is conjugated with that of the individual on the right hand. Epistylis also passes through encysted stages as indicated at Fig. 34, G and H.

The same mode of development was observed by Claparède in

Fig. 35.

Development of Urnula.

a parasite of the Epistylis, *i. e.*, *Urnula epistylidis* (Fig. 35), which, besides reproducing by fission, also produces ciliated

young. Fig. 35, B, *e*, represents the ciliated young within the body of the parent, B; Fig. 35, C, the free swimming ciliated young. In another specimen Claparède observed the interior of the body subdivide into several masses, as at Fig. 35, D. These masses increase in size and become filled with a number of small corpuscles, with active movements, which finally press through the walls of the Urnula. These are probably spermatozoa, as Stein considers Urnula as the male of Epistylis, contrary to the opinion of Claparède, who regarded it as a Rhizopod, though its ciliated young is, in the light of later studies, sufficient to prove that it is a ciliate infusorian.

As to the sexuality of the Infusoria, Balbiani has advanced the idea that they are in reality hermaphrodite, the nucleus representing the ovary, and the nucleolus the testis, the latter producing bodies which he regards as spermatozoa. Claparède regards this view as well founded, as it had already been suggested by himself, Lieberkühn, J. Müller and Stein that certain Infusoria contained spermatic particles, found not only in the nucleolus, but also in the nucleus, into which they had penetrated from the nucleolus. This has been observed in Paramecium, where, as Claparède quotes as Stein's opinion, that "Fecundation having been accomplished, these zoosperms disappear, and the nucleus then divides in a manner comparable to the segmentation of the egg into a certain number of segments, or reproductive bodies, destined each to give rise to an embryo. The Infusoria, then," adds Claparède, "are androgynous."

It appears, also from the observations of Balbiani, that the Infusoria, as Stentor, Paramecium, Vorticella, etc., have true eggs, each egg consisting of "two hollow membranous spheres, the smaller being enclosed within the other, and separated from it by a considerable interval." The smaller vescicle he regards as the germinal vesicle, and the larger as the vitelline membrane. After the fecundation, "at the end of four or five days, the development of the eggs is complete, and each, with the aid of reagents, displays in a very distinct manner its characteristic elements, namely, vitelline membrane, vitellus, germ-vesicle and germ-spot." Bütschli, however, it should be stated, denies that Infusoria produce spermatozoids which fertilize the nucleus. As to the development of the Acinetæ, self-fission is in them very are, while conjugation is very frequent.

There are, then, two modes of development among the Infusoria (Ciliata): —

1. By fission.
2. By production of internal ciliated embryo arising from eggs.

We have, then, for the first time among the Protozoa, if the observations of Balbiani be correct (though this is denied by good observers), truly sexual animals, producing true eggs and spermatic particles. The same animal reproduces both by fission and by the production of ciliated embryos. Most of them before producing embryos undergo fission. This is comparable to the alternation of generations among the Hydroids, Aphides, etc.

LITERATURE.

Ehrenberg. Die Infusionsthiere als volkommene Organismen, 1838.

Dujardin. Infusoires, 1841.

Stein. Infusionsthiere auf ihre Entwicklungsgeschichte untersucht. 1854.

——— Untersuchungen über die Entwickelung der Infusorien. (Wiegmann's Archiv, 1849.)

——— Der Organismus des Infusorien. 1867.

Claparède und *Lachmann.* Études sur les Infusoires et les Rhizopodes (Memoires de l' Institut National Genevois, 1858–61).

Balbiani. Recherches sur les Phénomènes sexuels des Infusoires. (Brown-Séquard's Journal de la Physiologie. 1861. Translated in Quart. Journ. Micr. Science. 1862.)

Clark. Mind in Nature. 1865.

Everts. Untersuchungen au Vorticella nebulifera. (Siebold and Kölliker's Zeitschrift, 1873.)

VIII. THE SPONGIÆ (PORIFERA).

We now come to animals whose bodies are composed of numerous cells, and which produce true eggs, sometimes even with a thin calcareous shell, and genuine sperm cells. The embryo sponge arises from eggs which undergo a total segmentation of the yolk. The free swimming larva later in its life becomes fixed, loses its external cilia, but retains its cellular walls, now composed of two layers, which are supported by silicious or calcareous needles or spicules developed in the inner layer.

To regard such an organism as a Protozoan, or even to compare it with a compound Radiolarian such as Sphærozoum, with its silicious spicules and aggregations of one-celled organisms, would not seem warranted. We have, in fact, in the light of the anatomical investigations of Lieberkühn, Carter and Clark, and the combined anatomical and embryological studies of Hæckel, Metschnikoff and Carter, no grounds for leaving them among the Protozoa. Indeed, one of the most striking illustrations of the value

of the knowledge of the early history of an organism is afforded by the embryology of the sponge. Hæckel's discovery that the larval sponge is a planula, though not homologous with the embryo polype or jelly-fish, enables the naturalist to at once decide that the sponge is not a Protozoan, but belongs to a type only less highly organized than the lower polypes, and with more analogy to the Radiates than the Protozoa.

If, under the guidance of the results of the studies of Lieberkühn, Carter, Clark, and particularly of Hæckel and Metschnikoff,

Fig. 36.

Axinella polypoides.

Fig. 37.

Axinella, with a parasitic polype, 2-3 natural size. After Schmidt.

we examine the structure of a sponge, we shall find that in its simplest form it is a hollow, vertical cylinder, fastened by its base, with the mouth opening upwards from a central gastro-vascular cavity, with ciliated epithelial cells lining the cavity, and possessing a surprising degree of individuality. There usually are several mouths, and the cavity usually opens into a labyrinth of chambers connected by passages through the cellular tissue; these round chambers being lined with ciliated epithelial cells. This

body is supported by a basket-work of interlaced needles of silica or lime, developed in the inner layer of cells of the larva.

Such, in brief, is the sponge. Does the fact that in the simplest, immature forms, we have quite a regular body-wall and a single cavity, compel us to range the sponges side by side and in he same natural division with the polypes and jelly-fishes, in the

Fig. 38.

Tethilla polyura. After Schmidt.

Fig. 40.

Hyalonema boreale. Nat. size; with part of stem enlarged. After Lovén.

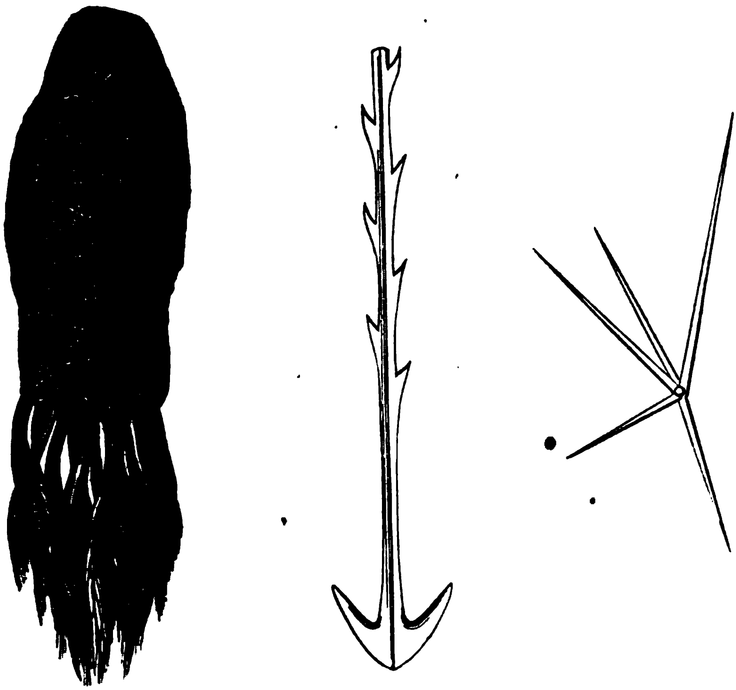
typical forms of which the central cavity acts as a true stomach and the outlet surrounded with tentacles acts as a mouth? Metschnikoff has shown that it would seem to be a violation of the existing principles of classification to place together animals so unlike. The sponges apparently represent a class lower than, but possibly equivalent, systematically, to the polypes and jelly-fishes.

Currents of water, created by the cilia and bearing along parti-

cles of food, enter through the system of mouths, and when the food is absorbed by the cells of the inner lining, they pass out through the larger openings. Both the larger and smaller "mouths" are capable of opening and closing.

The eggs and sperm cells are scattered at irregular intervals among the cells composing the body-walls; the spermatozoa are

Fig. 39.



Pheronema Annæ and Spicules. After Leidy.

in some species developed in "mother" cells, as in many of the higher animals.

The sponges are by Hæckel regarded as closely allied to the Hydroid polypes, members of the Cœlenterates, a division formed by Leuckart, including the polypes and acalephs. His reasons are based on the fact that the sponges are made up of two layers of cells (ectoderm and entoderm, or outer and inner layer) surrounding a central cavity, and that both reproduce by eggs and spermatozoa, and pass through a "planula" stage.

Fig. 41.

Hyalonema Sieboldii (½ nat. size). After Schulze.

Fig. 42.

Hyalonema with parasitic polypes, embedded half its length in the mud. After Gray.

Gegenbaur and some English naturalists have endorsed this view. Hæckel goes so far as to state that the only character ex-

Fig. 43.

Tuba labyrinthiformis, ½ natural size. After Lütken.

Fig. 44.

Corbitella, ⅔ natural size. After Lütken.

cluding the sponges from the Cœlenterates is the want of lasso cells,[4] but we have seen that the true Infusoria possess them.

[4] Eimer claims to have found true lasso cells in Reniera, a sponge observed by him at Capri; but Carter attributes their presence to a parasitic polype which he detected in this sponge. Eimer on other grounds claims that he has discovered a sponge which affords a passage into the Hydroids. "In an Esperia, in another silicious sponge allied to Myxilla, and in a horny sponge, the surface is studded with small chitinous tubes, which are external prolongations of a similar investment of the whole channel-system, becoming, however, more delicate below, and finally passing into a sarcode-like condition; each of these tubes is inhabited by a retractile, sac-like body, provided with ectoderm, a muscular layer, and entoderm, with thread cells, and with 6–12 long, unbranched tentacles, with cilia and thread cells; below, they pass successively into the common sponge-substance, and generally lie four in each channel, each, however, with

But Metschnikoff has shown that there is no true homology between the sponges and Radiates.

The sponges are divided into (1) the *Myxospongiæ*, represented by Halisarca; (2) the *Fibrospongiæ*, or the silicious sponges, represented by Axinella (Fig. 36, *A. polypoides;* 37, another species of Axinella), the fresh water Spongilla; Thethya, Tethilla (Fig. 38 *T. polyura*); Pheronema (Fig. 39, *P. Annæ* and spines); the glass sponges, such as Hyalonema (*H. boreale*, Fig. 40, from the

Fig. 45.

Dactyocalyx pumicea. After Lütken.

Arctic Ocean; Fig. 41, *H. Sieboldii;* Fig. 42, another Hyalonema, anchored in the mud by its silicious threads) the Venus flower basket, or *Euplectella aspergillum* from the Philippines; the Tuba (Fig. 43, *T. labyrinthiformis*) from the West Indies; the Corbitella from the Moluccas (Fig. 44); and Dactyocalyx (Fig. 45, *D. pumicea*[5]) from the West Indies. The third division of sponges comprises the calcareous sponges (*Calcispongiæ*) represented by the Sycon (*Sycandra ciliata*, Fig. 46), a common little white sponge found on our shores, and in the North Atlantic generally.

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its own special chitinous tube. In other sponges (Renieræ) these polypoids were found in a lower stage of evolution, with short or absent tentacles, thread-cells present or wanting, no muscular layer, chitinous investment sometimes strongly developed, annular and projecting—in other instances reduced to a delicate, almost sarcode-like membrane, or almost totally wanting. The idea of parasitism is, according to the author, quite out of the question; the 'polypoids' he constantly regards as the true nutritive zooids of the sponge, and the sponges in which they occur in a more rudimentary shape as intermediate forms, leading to the great majority of sponges without nutritive zooids of any kind." Lütken in Zoological Record for 1872. London, 1874.

[5] This and Figs. 36–38, 40–46, were kindly loaned me by Dr. C. F. Lütken, of the Royal Zoological Museum at Copenhagen. They are from the Tidsskrift for Populære Fremstillinger af Naturvidenskaben. 1871.

Development. Lieberkühn made the astonishing discovery, confirmed by Hæckel, that sponges were really hermaphrodite animals reproducing by eggs and sperm cells developed in the same individual sponge. Hæckel showed that they were probably developed from the inner (endodermal) layer of cells forming the body, being simply modifications of these endodermal cells, much as the eggs of the higher animals are modified epithelial cells. Fig. 47, from Hæckel, shows one of these cells (of *Sycortes quadrangulata*) with several spermatozoa mingling their protoplasmic contents with the protoplasm of the egg itself.

Fig. 46.

Sycandra ciliata, a calcareous sponge enlarged. After Schmidt.

The endodermal cell transforms into an egg, according to Hæckel, in the following manner. At first provided with a "collar" and flagellum much as in the Codosiga figured on page 42, it begins to draw these in until they disappear; then a nucleus (nucleolinus) appears within the nucleolus of the cell. The egg soon becomes detached from the body wall, and moves about, sometimes penetrating into the exoderm, or "emigrating, in the oviparous species, from the 'stomach' to be fecundated abroad."

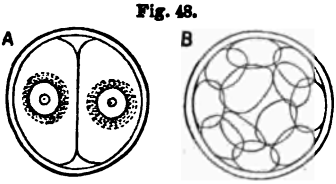
"The spermatozoa are apparently developed through repeated divisions of modified endodermal cells; the 'head' is formed by the 'nucleus,' the tail by the protoplasm of the minute sperm-cells."

Fig. 47.

Fusion of spermatic particles with egg of sponge. After Hæckel.

After fecundation of the egg, it begins to undergo self-division, splitting into two, four, eight, sixteen, etc., nucleolinated cells (Fig 48, total segmentation of eggs of Halisarca), the process being exactly as in the eggs of nearly all the higher animals including man. This stage of segmentation, like the mulberry mass of the egg after segmentation in the higher animals, Hæckel terms the Morula stage (from its likeness to the mulberry, Morus; see Fig. 48, after Carter). The cells of the

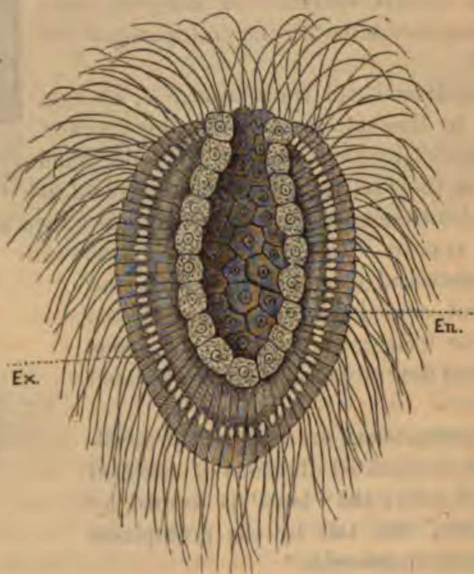
Fig. 48.



Segmentation of egg of sponge.

Morula afterwards become separated into two kinds, a few remaining round, the majority becoming long and prismatic, and provided each with a cilium (flagellum), by means of which it swims about and looks like a "planula" or larval jelly-fish. This stage Hæckel consequently calls the "Planula" stage. The next step is the formation of a "stomach" or internal cavity in the body of the ciliated larva. This stage Hæckel calls "Gastrula." Fig. 49, from Hæckel, represents the gastrula of *Leuculmis echinus*, as seen in optical section, the outer layer (ec-

Fig. 49.



Larva of a Sponge.

toderm) being composed of long prismatic, nucleated cells (*ex*) provided with a lash, while the cells (*en*) of the lining (endoderm) of the cavity are much larger and rounder.[6] After swimming about for a time it becomes fixed by the end of the body to some object, the cavity finally opening out by a mouth. The external cilia now disappear, and others become developed in the cells lining the interior of the cavity.[7] Afterwards the true sponge char-

[6] Metschnikoff shows that this "entoderm" is really an invaginated portion of Hæckel's "ectoderm."

[7] Metschnikoff observed on the contrary that the ciliated external cells are with drawn in the process of growth and line the cavity.

acter of the organism is revealed. The body-wall becomes perforated with pores, which open into the general cavity of the body, while currents of water are maintained by means of the cilia, and flow out through the so-called mouth. This is the "Protospongia" state, and when spicules of silex or lime are developed to strengthen the walls of the body, the young sponge is termed by Hæckel, the "Olynthus."

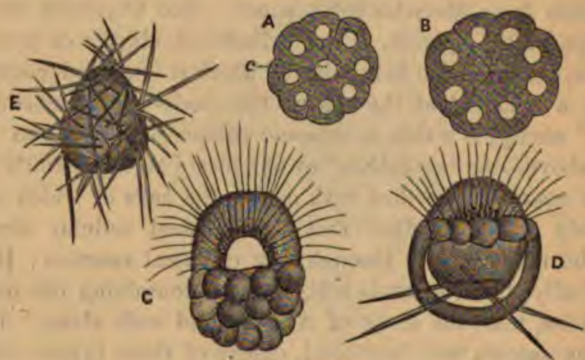
Thus following the course of development as Hæckel supposed to be the case with the calcareous sponges, for he, as Metschnikoff remarks, did not actually observe the stages after the formation of the ciliated larva we obtain a very clear idea of the typical structure of the sponge. I cannot do better than employ the condensed account of the discoveries of Hæckel given by Dr. Lütken in the "Zoological Record" for 1872, with a few corrections taken from Metschnikoff's paper. The Olynthus, the simplest type of the sponge, is a "cylindrical, clavate or pyriform, etc., tube, closed at the extremity by which it is affixed, commonly open by a 'mouth' at the other; the body-wall, enclosing the 'gastric' cavity, is a thin membrane composed of the two layers named above—the '*syncytium*' or exoderm [Metschnikoff's inner layer] a mass of sarcodine with nuclei, the cells of which are so completely fused together that the original cellular structure cannot be made visible through any chemical reaction; if torn mechanically, the fragments will, whether containing one or more or no nuclei, take the shape of Amœbæ and walk about. In this layer[8] the spicula are developed, chiefly of three types—simple, 3-radiate and 4-radiate, anchor-shaped spicula are rare (*Syculmis synapta*, anchoring the animal in the mud bottom); the stellate spicula sometimes occurring are foreign bodies, belonging originally to Didemnia (Ascidiæ). The spicula are invested with a delicate sheath of condensed sarcodine; they contain an axial filament, and are composed of concentric layers, like the silicious spicula; chemically they are composed partly of Co_2, CaO, partly of an organic substance ('spiculin'). The endodermal cells are, like certain flagellate Infusoria, provided with a collar and flagellum; they contain a 'nucleus' (with 'nucleolus'), and often one or two contractile 'vacuola' (water drops); though without 'mouth,' they both 'drink' and 'eat,' or receive

[8] Metschnikoff shows that the spicules really arise from the inner layer.

into their interior, not only fluid, but also minutely diffused solid matter (*e. g.*, carmine), probably through the soft exoplasm between the collar and flagellum. Liberated artificially, they also assume amœboid shapes and motions. On the endodermal cells devolve the whole of the nutritive (digestive, respiratory and secretory) functions; and there can be little doubt that both eggs and spermatozoa are modified endodermal cells."

Hæckel did not observe the development of the larva, his gastrula, into the young sponge. This gap has been filled by Metschnikoff. He observed the course of development in *Sycon ciliatum* (Fig. 50) from the segmentation of the yolk, through the larval state, up to the time when the sponge is fixed and the spicules are

Fig. 50.



Sycon ciliatum.

well developed; in fact, through nearly every important stage in its life. By making a section through the sponge he found eggs and embryos in different stages of development in springtime. The total segmentation occurred as Hæckel describes. Metschnikoff, however, observed that a small "segmentation-cavity" appeared in the egg (Fig. 50, A, c) which soon disappeared (Fig. 50, B). As a result of the process of division, a roundish embryo appears, which is made up of a large number of small cells. He was unable to study the mode of origin of the germ-layers. The free-swimming larva (Fig. 50, C) is an oval body, made up of two sorts of cells: those which are small, long and ciliated, and certain large round ones, much fewer in number. The first form a

sort of arch, with a hollow in the middle, surrounding which a large number of very fine brown pigment corpuscles are collected. The next change of importance is the disappearance of the cavity, the upper or ciliated half of the body being much reduced in size. Then the large round cells of the hinder part are united into a compact mass, leaving only a single row. The ciliated cells are gradually withdrawn into the body cavity. Fig. 50, D, shows this process going on. At this period also the larva becomes sessile, and now begins the formation of the sponge spicules, which develop from the non-ciliated round cells. Metschnikoff calls attention to the fact that at this early stage the Sycon passes through a phase which is persistent in the genus Sycyssa. The layer of ciliated cells are gradually withdrawn into the body cavity, until a small opening is left, surrounded with a circle of cilia. These cilia finally disappear, and a few more spicules grow out, and meanwhile the opening disappears. In the next stage (represented at D) a considerable (gastrovascular) cavity appears, which may be seen through the body-walls. At this time, by soaking the specimen in acetic acid, the body of the sponge was seen to consist of two layers, the inner layer of ciliated cells forming a closed sac, enveloped in the spicule-generating layer (representing the entoderm). At this time no mouth-opening was formed, though three-pointed spicules had appeared.

It results from Metschnikoff's observations that the body of the larval sponge is composed of two primary germ-layers, an "entoderm" and "ectoderm," the two germ layers about which we shall hear much more hereafter.

The observations of Carter, made on several additional species both of silicious and calcareous sponges, confirm the results of Metschnikoff as to the later history of the larval sponge, and those of Hæckel as to the mode of segmentation of the egg. Our Fig. 48, A (copied from Carter), shows the total segmentation of the yolk in *Halisarca lobularis* into two portions; these portions farther subdivide, as at Fig. 48, B, until an immense number of small embryonic cells are produced.

Carter observes that the embryos may be found at all seasons, from March through the summer. These observations are not difficult to follow out. We have, by tearing apart a species of Sycandra (or Sycon) perhaps *S. ciliata*, which grows on a Ptilota, found the planula much as figured by Hæckel, Metschnikoff and

Carter, and any one can with patience and care observe the life history of the marine sponges.

It seems, then, that the life history of the sponges consists of the following stages :—

1. Fertilization of a true egg by genuine spermatozoa; both eggs and sperm cells arising from the inner germ-layer.
2. Total segmentation of the yolk, or protoplasmic contents of the egg.
3. A ciliated embryo.
4. A free swimming "planula"-like larva, with two germ-layers, not, however, originating as in the true planula of the acalephs. The planula becomes sessile, spicules are developed in the hinder end of the body, afterwards a gastro-vascular cavity appears, constituting the
5. Gastrula stage.
6. A mouth and side openings appear and the true sponge characters are assumed.

LITERATURE.

Lieberkühn. Zur Entwickelungsgeschichte der Spongillen (Muller's Archiv, 1856.)
O. Schmidt. Die Spongien des Adriatisches Meeres. Leipsig. 1862–66.
Clark. Spongiæ Ciliatæ or Infusoria Flagellata. 1867.
Hæckel. Die Kalkschwämme. Eine Monograph. 2 vols. and atlas. Berlin, 1872.
Metschnikoff. Zur Entwickelungsgeschichte der Kalkschwämme. (Siebold and Kölliker's Zeitschrift. (Feb., 1874.)
Carter. Development of the Marine Sponges, etc. (Annals & Mag. Nat. Hist., Nov. and Dec., 1874.)

REVIEWS AND BOOK NOTICES.

THE SPIDERS OF FRANCE.[1]—Mr. E. Simon has just published the first part of a monograph of the Arachnida of France, forming an octavo volume of two hundred and seventy pages, with three plates. Beginning with the Araneæ he describes the Epeiridæ, Uloboridæ, Dictynidæ, Enyoidæ and Pholcidæ. This arrangement is not meant for a natural one, but has been adopted because the work on these families was first finished by the author. The introduction is promised in a future part, but the present volume begins with a short review of the principal descriptive works on

[1] Les Arachnides de France. Par E. Simon, Tome 1, Paris, 1874, with 3 plates 8vo. pp. 270.

European spiders, a list of definitions of terms used in descriptions and some general remarks on classification. The arrangement of families adopted by Simon is the following.

1st suborder. Araneæ oculatæ; Attidæ; Lycosidæ; Oxyopidæ.

2nd suborder. Araneæ veræ; Sparassidæ; Thomisidæ; Palpimanidæ; Eresidæ; Epeiridæ; Ulobaridæ; Therididæ; Pholcidæ; Hersilidæ; Urocteidæ; Eryoidæ; Agelenidæ; Dictynidæ; Drassidæ.

3rd suborder. Araneæ graphosæ; Scytodidæ; Dysderidæ;

4th suborder. Araneæ theraphosæ; Filistatidæ; Avicularidæ.

The first suborder is founded on the great development of the head and front legs in the Attidæ, the third is the Senoculinæ of Blackwall, the fourth the Theraphores of Walckenaer, and the second comprises all the other families.

For convenience in identification, tables are given of the most prominent characters of the genera of each family and the species of each genus.

The plates give a figure of one spider from each genus in the Epeiridæ, Ulobaridæ, and Dictynidæ, and a few enlarged figures of feet, palpi and copulatory organs.

The second part containing the Urocteidæ, Agelenidæ, Thomisidæ and Sparassidæ, is to be published next April. The work will be quite useful to students in this country.—J. H. E.

Wheeler's Survey of the Territories.[1]—Judging by the present report, a good deal of geological and biological work has been accomplished in connection with the regular topographical work of the survey. Three parties were in the field, and explored portions of Utah, Arizona, Colorado and New Mexico. Considerable geological work was done, while Dr. J. T. Rothrock and assistant John Wolfe collected nearly 12,000 specimens of plants, representing over 1,100 species. A goodly number of animals were collected, and have been distributed to specialists. The report is accompanied by a number of descriptions of fossil vertebrates from New Mexico by Prof. Cope.

[1] Annual Report upon the Geographical Explorations and Surveys west of the 100th Meridian in California, Nevada, Utah, Arizona, Colorado, New Mexico, Wyoming and Montana. By G. M. Wheeler, U. S. Engineer. Washington, 1874. 8vo, pp. 130, with a map.

Embryology of the Pill-bugs.—An addition of much value to our knowledge of the mode of growth of crustacea is afforded by a Russian embryologist, Dr. Bobretzky in Siebold and Kölliker's "Zeitschrift." He figures the early stages of the pill-bug, or *Oniscus murarius*, of Europe.

The Entomostraca.— An extended and beautifully illustrated memoir by Prof. A. Weissmann, on the structure of *Leptodora hyalina*, a little European Entomostracan, or water-flea, appears in the last number received of Siebold and Kölliker's "Zeitschrift."

BOTANY.

A New Material for Paper.—Considerable attention has recently been called in England to the capabilities of the *Zizania aquatica* as a material for paper. This grass grows in large quantities in swamps on the Canadian shores of Lakes Ontario and Erie, and is known to the native Indians under the name of "Tuscarora," the grains affording an article of diet which is both highly nutritious and palatable, and furnishing food to enormous flocks of wild swans. The culm grows to the height of eight or ten feet, and is of great strength and tenacity. It is said to possess all the good qualities of the "esparto" from the shores of the Mediterranean, now so largely used for paper making in England, and besides, to contain less silex, to require fewer chemicals for its purification, and to make a paper which takes printers' ink with greater sharpness. The great obstacle to its exportation is the heavy freight in consequence of its great bulk; but there is little doubt that if it could be at least partially prepared on this side the water, it might become an important article of commerce. It is stated that a company has been formed for the purpose of obtaining a concession of the land from the Canadian government. The grass is nearly allied to the rice belonging to the tribe Oryzeæ. — A. W. B.

The Movement of Water in Plants. — Dr. W. R. McNab of Dublin has performed a fresh series of experiments on the rate of motion of the sap in plants, and the transpiration of water from the leaves. The plants selected were the cherry-laurel (*Prunus laurocerœus*), elm and privet; and the results obtained were as follows: 1. That under favorable circum-

stances, a rate of ascent of 40 inches per hour can be obtained. 2. That, contrary to the generally received opinion, direct experiment has shown that the upward rapid current of water does not cease in the evening. 3. That checking the transpiration for a short time by placing the branch in darkness does not materially impede the rapid current of water. 4. That the removal of the cortical tissues does not impede the rapid current in the stem, which moves only through the woody (xyleus) portion of the fibro-vascular bundles. 5. That a well-marked rapid flow of fluid will take place in a stem after the removal of the leaves. 6. That fluid will rapidly flow downwards as well as upwards in the wood (xyleus) portion of the fibro-vascular bundles, as seen in a branch in which lithium citrate was applied at the top. 7. That pressure of mercury does not exert any very marked influence on the rapidity of flow, in the one experiment made with a pressure of 110·53 grammes of mercury. — A. W. B.

THE RESURRECTION FERN. — *Polypodium incanium*, the commonest of all the ferns of Florida, is often called the resurrection fern. It grows mostly upon the trunks and branches of the oaks, and I have seen the roofs of old buildings covered with it. During dry weather it shrivels up, and has the appearance of being dead. While in this condition I secured some, wrapped them up in paper, and sent them in April last to Cambridge. On my return to that place in September last, the plants, after having moist moss placed about their roots, were secured to blocks of oak wood hung up in the greenhouse of the Botanic Garden. The leaves unfolded and assumed a bright green color. They now appear to be in a healthy condition. — E. PALMER.

THE TRUE PROCESS OF RESPIRATION IN PLANTS. — M. Claude Bernard pointed out long ago that the process ordinarily described as that of respiration in vegetables, the decomposition of the CO_2 of the atmosphere, is not properly of this nature at all, but is rather a process of digestion; the true process of respiration being of a precisely similar character in the animal and vegetable kingdoms, viz., an oxidation of the carbonaceous matters of the tissues. M. Corenwinder of Lille in France, has recently confirmed this view from a series of observations on the maple and lilac, proving that true respiration is always going on in a plant, even when concealed by the greater activity of the decomposition

of the CO_2 by the parts containing chlorophyll. He distinguishes two periods in the vegetative season of the plant: — the first period, when nitrogenous constituents predominate, is that during which vegetation is most active; the second, when the proportion of carbonaceous substance is relatively larger, is the period when respiration is comparatively feeble, the CO_2 evolved being again almost entirely taken up by the chlorophyll, decomposed, and the carbon fixed in the process of assimilation or digestion. He found that the proportion of nitrogenous matter in leaves gradually diminishes, while that of carbonaceous matter increases, between autumn and spring. — A. W. B.

MARTENIA PROBOSCIDES.—This is a very common plant in Arizona and is very productive. Its large seed pods after being deprived of their epidermis are used by all the Indian tribes of Arizona to ornament their willow baskets. The method resorted to is first to soften by means of water the black pods which are very hard. They readily soften, and are then straightened, split into the requisite strips and worked into willow baskets to form the black ornamentations seen in those made by all the tribes of Arizona.—EDWARD PALMER.

ZOOLOGY.

AN ADDITIONAL CHARACTER FOR THE DEFINITION OF RHYNCHOPHOROUS COLEOPTERA.[1] — On two former occasions I have invited the attention of my colleagues of the Academy to the relations which the Rhynchophorous Coleoptera bear to the other divisions of that order of insects. In the first of these I endeavored to show that they formed a group which was equivalent to all the others combined. The defining character of the group I stated to be, that the posterior lateral elements (the prothoracic epimera), of the under surface of the prothorax, coalesced on the median line, in such a manner as to form a longitudinal suture behind the end of the prosternum; in all other Coleoptera[2] the prosternum ends in a vacant space, or extends so as to take part in the articulation between the pro- and metathoracic segments. In the second memoir I attempted a sketch of the manner in which the group might be naturally divided into series and families.

[1] Read before the National Academy of Sciences, at Philadelphia, Nov. 5, 1874.
[2] Except in Cossyphus and a few Colydiidæ.

During the progress of the investigations which will terminate in the classification, according to the scheme there proposed, of the genera and species by which the Rhynchophora are represented in our fauna, I have been led to observe an additional character serving to define this great and important complex of genera. This character strengthens greatly the opinion I first announced concerning its systematic value, as an equal of all the other Coleoptera combined.

On separating the head of a Rhynchophore, it is seen that the cranium (I use this word for want of a better term) is globose, and always presents a distinct trace of a median suture on the under surface, corresponding with the gular sutures of other Coleoptera. In the latter, however, these sutures diverge either before or behind, and rarely (Silphidæ and Staphylinidæ), approximate at the middle of their course. Whether the differences in direction of these sutures may or may not, when carefully studied, give indications for the definition of the series into which the normal Coleoptera are now divided upon other characters, I cannot now say. But this much I can assert positively, that in no other but the Rhynchophora, do the lateral elements of the under surface of the head coalesce on the median line, so as to form a straight longitudinal suture extending to the posterior limit of the chitinous part of the head.

In most of the Coleoptera the gular sutures diverge behind, and even when they are obsolete, their posterior termination is indicated by a nick or irregularity in the outline of the infero-posterior margin of the cranium. In the Ptinidæ and Bostrichidæ, by a remarkable exception, the sutures, though distant in front, converge behind.

It will not be in my power, for some time to come, to follow this train of investigation to its limits, and I now make known these imperfect observations in the hope of inducing observers, who are less burdened with a great mass of material urgently pressing for classification, to give some attention to the valuable characters here indicated. — J. L. LeConte, M.D.

Note on Telea Polyphemus.—My note on the synonymy of this species on page 753 of Vol. viii, of the American Naturalist, was printed without proof having been sent to me. In the second paragraph, line six, "this Bombycid" should read "the

Bombyces." No species of Attaci have yet been discovered in Cuba; the very extensive collections of Lepidoptera made in that Island by Professor Poey and Dr. Gundlach having been examined by me (see Grote, on the Bombycidæ of Cuba, Proc. Am. Ent. Soc. Phil., 5). As stated, Linné has no species under the name *Polyphemus* in his 10th or 12th Editions, or in the Mus. Lud. Ulr., but I find that in the 13th Edition, p. 2402, No. 461, he cites a species under that name. Linné gives references to Fabricius and to Cramer and undoubtedly intends our species. He says: "*Habitat in America boreali, Jamaica.*" The preceding species is his *Paphia*, of which he says: "*Habitat in Asia*," and there is no reference, doubtful or otherwise, to Catesby. So that I repeat my former conclusion that there can be no reasonable doubt that Linné's *Paphia* is a distinct species from our *Polyphemus*, and that we are not justified in surrendering the latter name. I have recently given the synonymy of the North American forms of the group (*Attaci*) to which Polyphemus belongs in the Transactions of the American Philosophical Society.—A. R. Grote.

Notes on Californian Thrushes.—The recent appearance of the excellent work by Baird, Brewer and Ridgway, on the "History of North American Birds," makes it necessary for me to explain some discrepancies between my statements in the "Ornithology of California" and the views taken by them in relation to the two common brown thrushes of California.

1. A reference to Baird's report, in Vol. IX, P.R.R. series, will show that the specimens collected on those expeditions led him to believe that *T. ustulatus* was limited to the "Coast region of Washington Territory and Oregon," while the *T. nanus* was confined to the "Pacific Slope, from Ft. Bridger and Ft. Crook (about lat. 41°) to the valley of the Gila and Cape St. Lucas.[1] In the Ornithology of California I merely extended the range of *ustulatus* to "San Francisco in winter," having observed it there (as I supposed) while in the Colorado valley, and at San Diego I only found *nanus* at that season. Relying too much on the authority of the Pacific Railroad Report, I assumed that *ustulatus* was a northern form only, and *nanus* a southern and consequently dwarfed race (without reference to their eastern allies). I may

[1] Townsend however obtained the type without doubt at Columbia River.

remark, that in the woods it is impossible to distinguish between them at the distance such shy birds usually keep from the observer.

2. At the time I wrote the Ornithology of California, I had collected only *nanus* in winter, and with the above mentioned impressions, too hastily concluded that they remained in the state all summer, while the *ustulatus* retired to more northern regions. Afterwards when collecting the nests and eggs assigned to *nanus*, it was inconvenient, and seemed unnecessary to preserve the birds also. I will admit therefore, that I may have described those of *ustulatus* as belonging to *nanus*.

3. That there is still reason to believe that *nanus* does not always build on the ground is shown by the note in Vol. III, Hist. N. A. Birds, p. 499, describing the nest of "var. *Audubonii*" on a tree, and in a region remarkable for dryness.[2]

4. The statement on page just quoted, that "Dr. Cooper has sent to the Smithsonian Institution skins of his *T. nanus* and they prove to be *T. ustulatus*," is not quite correct. I sent *one* skin from near San Bucnaventura with notes showing its differences from *T. nanus* (which I also obtained there), and my uncertainty as to what to call it. Prof. Baird wrote that it was *T. ustulatus*, although I had supposed, from its very olivaceous hue, that it might be *Audubonii*. I had not considered it *nanus*, and it was so much less brown than the *ustulatus* I obtained in Washington Territory that I did not suppose it the same. It must be considered a link between them and the var. *Swainsonii*.

5. The facts now stand exactly in reverse of the range given in the Report on Birds in the Pacific Railroad Survey. Thus *ustulatus* is the *summer* species of California as well as northward, breeding from Alaska south to lat. 35°, near the coast and in low grounds. *Nanus* is the *winter* species of California, retiring north and perhaps to the high mountains in summer, while in winter it only reaches Cape St. Lucas, *ustulatus* going entirely south of the United States, and as far as Guatemala.

6. In southern Californian specimens there is not so marked a difference between the color of the tail and back in *ustulatus* and *nanus* as to distinguish them strongly without comparison, nor

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[2] Audubon and Wilson also described the nest and eggs of var. *Swainsonii* much as I did those of var. *nanus*.

can I give any differences in song, unless I suppose that *nanus* is quite silent while with us, and that all my notes on songs belong only to *ustulatus*. They are easily distinguishable by measurements.

7. Admitting the determinations of the authors quoted, the law of priority requires us to call the species *T. ustulatus* and var. *Swainsonii*, also *T. nanus* and vars. *Pallasii* and *Audubonii*. It is however a question not decided by them, whether the two species of Peru are identical with those of North America. If found south of the equator, they must be supposed to migrate toward the south pole, if at all, and there may even be two or three races of each in South America, corresponding to longitudinal differences in climate. Though quoting Fauna Peruana they do not give localities for ours south of the equator. Do *T. minimus* Lafr. and *T. guttatus* Cab. cover the Peruvian species? or is any similar species found there?—J. G. Cooper.

Ascending Process of the Astragalus in Birds.[1]—Mr. Morse first described the ascending process of the astragalus in birds, as seen in the hen. The astragalus in birds coössifies early with the end of the tibia, and this process, as it has been called, ascends as a spur from the upper side of the astragalus in front of the tibia. In certain extinct reptiles, like Hypsilophodon, Lælaps, and others, the ascending process of the astragalus shows itself as an avian character.

A few years ago Prof. Wyman discovered that this process had an independent centre of ossification, and therefore could not be a process of the bone. Mr. Morse had interpreted this bone as the intermedium of Gegenbaur. The intermedium is a tarsal bone, occupying a position between the astragalus and calcaneum. In the Saurians, turtles, and other reptiles this bone is well seen. In certain amphibians as in the salamanders, the bone is long, wedge-shaped, and partially projects between the tibia and fibula.

Mr. Morse has expressed his belief that the ascending process of the astragalus represented the intermedium of reptiles. He had published in the "Annals of the New York Lyceum of Natural History" a theoretic figure of the proper position of this bone in birds, comparing it with the intermedium of certain salamanders.

[1] Abstract of a paper read at the Hartford meeting of the American Association for the Advancement of Science, by Edward S. Morse.

He explained its position in front of the tibia as a supposed process of the astragalus, by calling attention to the excessive tendency to anchylosis in birds. The widening of the tibia to include all the tarsals within its width necessarily brings the intermedium in front of the tibia, and, as it early unites with the astragalus, has naturally been mistaken.

Mr. Morse had been able to confirm his opinion regarding the nature of this bone in studying the embryos of the common tern at Penikese Island. In the embryo bird the intermedium appeared as a long oval bone between the astragalus and calcaneum, passing up between the tibia and fibula as seen in the lower reptiles.

In this connection it is interesting to observe that in the mammalia the intermedium does not occur, and Gegenbaur has expressed the opinion that the astragalus of mammals represents the astragalus and intermedium united. These investigations might possibly go to confirm that opinion in the fact that in reptiles the intermedium is separate; in birds it is separate in the young bird, but connected with the astragalus in the adult state, while in mammals, if Gegenbaur be right, it is always so connected.

GEOLOGY.

RETURN OF PROFESSOR MARSH'S EXPEDITION.—Professor Marsh and party returned to New Haven, Dec. 12th, after an absence of two months in the West. The object of the present expedition was to examine a remarkable fossil locality, discovered during the past summer in the "Bad Lands" south of the Black Hills. The explorations were very successful, notwithstanding extremely cold weather, and the continued hostility of the Sioux Indians. The latter refused to allow the expedition to cross White River, but a reluctant consent was at last obtained. They afterward stopped the party on the way to the "Bad Lands," attempted a night attack on their camp, and otherwise molested them, but the accompanying escort of U. S. troops proved sufficient for protection. The fossil deposits explored were mainly of Miocene age, and although quite limited in extent, proved to be rich beyond expectation. Nearly two tons of fossil bones were collected, most of them rare specimens, and many unknown to science. Among the most interesting remains found were several species of gigantic *Brontotheridæ*, nearly as large as elephants. At one point these bones were

heaped together in such numbers as to indicate that the animals lived in herds, and had been washed into this ancient lake by a freshet. Successful explorations were made, also, in the Pliocene strata of the same region. All the collections secured go to Yale College, and will soon be described by Professor Marsh.

Summer School of Geology.—The great difficulty that all students of practical geology meet at the outset of their career is to obtain proper instruction in the methods of working in the field. With a view to meet this need the teachers of geology at Harvard University have determined, with the consent of its governing body, to begin a system of summer instruction intended for the proper geological training of persons having sufficient preliminary knowledge to pursue field studies with profit. The school will be established in a camp to be formed in the state of Kentucky, in the immediate neighborhood of Cumberland Gap. This place offers great advantages for the pursuit of such studies. In that neighborhood a section from the Potsdam sandstone to the middle carboniferous can be easily traced, and it is in the midst of the noble mountain structure of the Appalachians, and affords great advantages for the study of dynamic geology. At the same time the situation is entirely healthy, being elevated more than fifteen hundred feet above the sea, thus avoiding all malaria and the extreme heat of lower regions.

The instruction will include lectures on different subjects connected with geology, by a competent corps of instructors, and practice in field work. Opportunities will be thus afforded for the study of dynamic geology, paleontology, chemical geology, with something of zoology and botany.

Students will be required to pay in advance for the instruction and use of camp furniture, the fee of fifty dollars, and will also be required to pay weekly in advance the actual cost of their subsistence, which is expected not to exceed three dollars per week.

The first term will be continued for about ten weeks, or from July 1st to Sept. 1st, 1875. Transportation of students from the nearest railway stations in Kentucky and Tennessee will be provided at actual cost. An effort will be made to secure a reduction of fare to students travelling to and fro from the camp.

This school is meant especially for teachers of natural science, and those who are desirous of pursuing the study of geology in a

practical and efficient fashion, and it will therefore be limited to persons of some training fitting them for such work. The number will be limited to twenty-five, and the school will not be begun if there are less than ten applicants. Persons desirous of joining the school should apply to F. W. Harris, President's Secretary, Harvard University, Cambridge, Mass.—N. S. S.

Ancient Lake Basins of the Rocky Mountains.—The existence of several large fresh water lakes in the Rocky Mountain region, remarks Prof. Marsh (in the American Journal of Science and Arts, Jan., 1875), is now well established, mainly through the researches of explorers whom the striking scenery of the "Bad Lands," or the extinct animals entombed in them, have attracted thither. The oldest are of Eocene age. The one best known forms the Green River basin, and the sediments are at least 6,000 feet in thickness. The animal remains found in these strata are those of tapir-like mammals, monkeys, crocodiles, lizards and serpents, and betoken a tropical climate. The lake basin of the "Bad Lands" of Nebraska is of Miocene age, and the strata are about 300 feet thick. The assemblage of animals indicates a climate less tropical than that of the Eocene lakes, as seen in the absence of monkeys, and the scarcity of reptilian life. The Brontotheridæ, the largest known Miocene mammals, are peculiar to the lower strata of this basin. The late tertiary or Pliocene basin, Marsh calls the Niobrara basin; it extended from Nebraska nearly to the Gulf of Mexico. The strata are nearly or quite 1,500 feet thick. The fauna indicates a warm temperate climate, the more common animals being a mastodon, rhinoceroses, camels, and horses, the latter being especially abundant.

ANTHROPOLOGY.

Copper as a Preservative of Animal and Vegetable Substances.—In examining an old Indian burying ground at Harpswell, Maine, several pieces of leather and strips of nicely twisted grass fibres were found which were fastened together at the sides with a tough grass thread passing through at intervals about an inch, though some of them were woven together. With these were embedded several copper tubes, and some thin sheets of copper; the corroding of the latter so impregnated the former that they

were in a good state of preservation; the pieces exhibiting the best marked effect of the copper were the strongest. The articles of which these pieces once formed a part had long since gone to decay; not coming in contact with the copper they were not spared to become articles of curiosity or of study to the ethnologist.—E. Palmer.

MICROSCOPY.

Ross' New Microscopes.—The adoption by this great house of the Jackson model of stand (which has long been very generally preferred in this country if not everywhere), in place of the transverse bar model which had come to be familiarly known as the Ross style, is an innovation of sufficient importance to attract special notice, and, we may add, congratulation. The magnificent workmanship of the old Ross stand is no secret and is a sufficient assurance of the mechanical excellence of the new ones, while the fact that they are designed by Mr. Wenham leaves nothing to be said as to their microscopical efficiency. The new stands, while adhering substantially to the Jackson model, combine some of the best features of the previous stands of Ross, Powell & Lealand, Ladd, and other makers.

The Ross' new patent object-glasses (devised by Mr. Wenham) are believed by the makers to have so well proved their superiority that they are now exclusively offered, and the old construction abandoned, from the $\frac{1}{2}$ inch upwards.

Very Thin Covering Glass.—Mr. G. J. Burch, of the Quekett Club, recommends the following procedure for producing very thin covers, not for general use, but only when excessive thinness is required. Seal up the end of a $\frac{1}{4}$ inch glass tube in a blowpipe flame, and continue to heat it until so soft as to require turning to prevent its falling out of shape; then remove it from the flame and blow into it strongly until it swells, at first slowly and then suddenly, into a very thin bubble of glass, of perhaps four inches diameter. When cold it is to be broken in pieces, and the pieces cut to shape with a writing diamond. When perfect flatness is required, lay a piece on a flat strip of platinum foil and place it for a moment in a Bunsen flame, which, at a red heat, will both flatten and anneal it. A piece of this glass measured $\frac{1}{2500}$ inch $=$·0004 inch, while Dr. Pigott's measurement of the thinnest glass in his possession was ·0022, which is $5\frac{1}{2}$ times as thick.

False-light excluder for Objectives.—Mr. Wenham's experiments upon the aperture of objectives, cutting off stray light by a perforated stop surrounding the focal plane of the objective, have suggested to Mr. Ingpen the usefulness of a similar contrivance for cutting off false light in objectives in actual use, and thereby preventing that milkiness of field which mars some otherwise excellent objectives. He slips over the objective a cap having a perforation a little larger than the field of the objective. When this cap is slipped down to the cover-glass, the full aperture of the lens is used and stray light excluded. The cap, by slipping it up toward or to the objective, may be made useful to secure a variety of reduced apertures. Such a contrivance which has hitherto been used in connection with micro-spectroscopic work is evidently capable of a more extended usefulness.

Staining Vegetable Tissues.—Persons unaccustomed to microscopical manipulation suffer much loss of time in working from such superb books as those of Beale and Frey, partly in selecting from the great wealth of material and partly from the necessary omission of minute details in the way of working directions. Of staining solutions, for instance, the beginner is at a loss to choose from the pages of excellent formulas, and is not unlikely to begin with the least suitable one; and, partly for this reason, few beginners are aware of the ease with which the modern methods of staining may be employed, or of the exquisite results attainable. Such will be glad to use the following hints, which are mainly abstracted from a paper by Dr. Christopher Johnston in the "Monthly Microscopical Journal."

For staining animal tissue carmine succeeds perfectly, and logwood gives also beautiful results, but aniline is unsatisfactory; while for vegetable work logwood-violet and aniline-blue are preferred to carmine, being easier to work and pleasanter to study, especially by lamplight.

Logwood staining was introduced by Boehmer, who used solutions of hæmatoxylin and alum, mixing them in small quantities when needed for use. Dr. Frey simplified the plan by mixing logwood and alum solutions until a violet color was produced, filtering the solution thus prepared, and keeping it for use when required. Dr. Arnold's plan, which is the most convenient, is to pulverize one part of extract of logwood and three parts of alum in a mortar,

and gradually add water so as to form a saturated solution, some of the powder being left undissolved. When filtered this should be of a dark violet color; if a dirty red, add more alum. After standing a few days add one-fourth of its bulk of 75 per cent. alcohol. Should a scum form on the surface, add a few drops of alcohol and filter.

Ordinary aniline blue is insoluble in water, but made soluble by the addition of sulphuric acid; but it may now be obtained in soluble form at the color shops, and a one per cent. aqueous solutifin of the soluble blue, with the addition of a little alcohol and a trace of oxalic or acetic acid may be used, or the solution sold as "Bower's Blue Ink," may be slightly acidulated and used instead.

The specimen, whether a section or a thin leaf, if it has not been blanched by previous maceration in alcohol, is decolorized by soaking in Labarraque's solution of chlorinated soda until perfectly achromatic and transparent, and then soaked in distilled water for an hour or two. It is next soaked in a three per cent. aqueous solution of alum, then in the logwood solution (diluted with twenty-five per cent. alcohol if a slight or slow effect is desired); when sufficiently stained it is washed in the alum solution, and then transferred through alcohol and oil of cloves, to damar varnish or a chloroformic solution of balsam. Or else the bleached and washed specimen is soaked in a three per cent. solution of oxalic acid in fifty per cent. alcohol, then in the blue fluid until intensely colored, washed in ninety per cent. alcohol to remove the superfluous aniline, and transferred promptly through absolute alcohol and oil of cloves to damar or the balsam solution. A small weight is placed upon the cover, and a temporary label on the slide while the balsam hardens.

The logwood stainings may be mounted at leisure and at any time, but those of aniline must be completed at once or the color will wash out.

A METHOD OF PREPARING AND MOUNTING SUITABLE INSECTS FOR MICROSCOPICAL EXAMINATION.[1]—After procuring the insect, place it under a tumbler or suitable vessel with a few drops of ether; when dead, wet it with alcohol, and place it in liquor potassæ of the strength of 1 oz. (troy) fused caustic potassa and 1 pint distilled water.

[1] Read before the Memphis Microscopical Society, December 17, 1874.

Let it soak in this liquid until the skin or external part is soft, and the internal substance in such a condition that, upon slight pressure, the insect can be evacuated by the natural, or, if necessary, an artificial opening. This is best done under water, and a white plate is best to use.

When this is effected the object is to be cleaned. Have a camel's hair brush in each hand; with one hold the object, and with the other brush every part of the insect, and on both sides; float it on a glass slide, and dispose each part in a natural position, either creeping or flying.

Cover this slip with another glass slip of the same size, and press gently together, using only sufficient force to make it as thin as possible without crushing or destroying it.

Confine these two glasses, the insect being between, with a fine brass wire as a string, and place it in clean water, to remain twenty-four or thirty-six hours; this will give the insect a position which is not easily changed, and it is therefore proper that the position be such as you desire when finished. Remove the string, and open the glasses carefully under water, and float the insect off; give it another brushing, and let it remain a few hours to remove the potassa.

Transfer to a small but suitable vessel containing the strongest alcohol that can be obtained, pursuing the same course as with the water, placing between glass slips, tied together, and letting it remain about twenty-four hours.

Transfer to a vessel containing spirits of turpentine. It is to remain in this, kept between the glasses, until all the water is removed. While in the turpentine, the insect is to be released several times and the moisture removed from the glasses, and the insect again confined.

When no moisture is visible surrounding the insect, heat the glass slips containing the insect over a spirit lamp until the contained turpentine nearly boils, when if any moisture be present, it will show its presence when the glasses are cold.

If free from moisture it is ready for mounting: float it on a suitable slide from the turpentine; drop a sufficient quantity of balsam upon it; examine, and if no foreign substances are present, heat the cover slightly, and apply in the usual way.

After a day or two, heat the slide moderately, and press out the surplus balsam, and place a small weight upon the cover while drying.

After the lapse of a suitable time, remove the surplus and clean the slide.

In all the operations the utmost cleanliness is to be observed; the liquids used to be frequently filtered and kept from dust, and a large share of patience will be found necessary.—THOMAS W. STARR, 324 *Chestnut St.*, *Philadelphia*.

DISTINGUISHING BLOOD CORPUSCLES.—The ordinary method of soaking out the shrivelled and distorted cells from a dried blood stain or clot, and then measuring their diameter under a suitably high power, is conceded to be satisfactory in many of the most frequently occurring cases (for instance, Dr. J. G. Richardson, who has been for several years a prominent advocate of the reliability of this method of distinguishing human blood, under high powers from that of certain domestic animals, has recently shown by numerous experiments the feasibility of thus distinguishing the blood of man, ox and sheep); but it fails when the corpuscles approach each other too nearly in size. It also gives unsatisfactory results with the oval nucleated corpuscles of reptiles, etc., which, when swelled by soaking, do not arrive at their original condition. Dr. R. M. Bertolet of the Philadelphia Hospital is represented as advising the following method of staining these corpuscles, which is applying one of the chemical tests for blood in a new way and with great precision. The blood is moistened with slightly acidulated glycerine, and then carefully irrigated with an alcoholic solution of guiacum resin, and finally a small quantity of ethereal solution of ozonic ether (peroxide of hydrogen) is flowed beneath the cover. By this procedure the whole corpuscle is stained of a uniform color which varies in different corpuscles from a light sapphire to a deep blue, except in case of the nucleated corpuscles in which the nucleus assumes a distinctly different tint from the rest.

EMBEDDING TISSUES.—Mr. R. Packenham Williams, in a paper "On Cutting Sections of the Eye of Insects," read before the Queckett Club, advises that the head, after hardening in alcohol, should be embedded in a mixture of butter of cocoa, bleached beeswax, and a little new Canada balsam. This mixture melts at about 120°, and may be removed from the sections, after cutting, by gently warming them in turpentine. The cutter used in connection with this compound should be wetted with turpentine while making the sections.

SPHÆRAPHIDES. — Professor George Gulliver calls attention in the "Monthly Microscopical Journal," to the hitherto unnoticed sphæraphides in *Leonurus cardiaca*, and also to the two kinds of sphæraphides occurring in this species as well as in *Urtica dioica*, *U. ureus*, *Parietaria diffusa* and *Humulus lupulus:* one kind, the larger and smoother, occurring in the blades of the leaves and consisting chiefly of carbonate of lime; the other kind, smaller and more roughened on the surface, occurring in the fibro-vascular bundles of the leaf and in the pith, and consisting of oxalate of lime except in *L. cardiaca* in which they are composed chiefly of carbonate of lime and in which they are wanting in the pith. Boiling the parts in caustic potash solution discloses these crystals admirably even when not otherwise easily found, as in the case of the leaf of *Ficus carica*.

SPIDERS' WEB.—Mr. H. J. M. Underhill publishes in "Science Gossip" an interesting microscopical study of the spider's web and the mechanism by which it is produced. He finds that of the two to four pairs of spinnerets or web-forming papillæ possessed by spiders, the British species have at least three pairs. The first, or upper pair of spinnerets, produce plain threads of the largest size which are stretched taut from point to point to form the foundation of the web, especially at the edges where great strength is essential; these threads are often doubled or trebled for greater seeurity. The spinnerets of the second pair are somewhat similar but smaller, and produce a smaller but otherwise similar thread. The third pair differs notably in structure, and produces a thread which is either elastic and studded with viscid globules, or is slack, irregular and curled, being in either case adapted for entangling and holding the insect prey. In the common house spider (*Tegenaria domestica*) there are about three hundred and sixty silk-glands each furnished with a separate duct and terminating in a silk tube at the extremity of a spinneret. The first pair of spinnerets has about sixty of these glands, the second pair eighty, and the third pair two hundred and twenty, which are more complicated in structure, though much smaller than the others. In spiders which have four pairs of spinnerets the thread of the fourth pair is somewhat like that of the second, and the aggregate number of silk tubes is greatly increased, being in *Ciniflo atrox* about twenty-six hun-

dred. Thus each pair of spinnerets is calculated to produce a different kind or size of thread; contrary to the common belief that each thread is formed by a coalescence of silk from all, in which case the change from viscid to plain thread would depend in some obscure manner on the will of the animal. Nor do those drops of silk which are simultaneously produced coalesce into a homogeneous thread, as a web under a high power will show many of the threads frayed like a worn rope, and an unfortunate fly is not bound by the coils of a single thread but by a broad band of many detached threads, from the tips of the six spinnerets arranged in a line, thrown rapidly around it.

Coarse Lines on Diatoms.—Mr. F. Kitton, the valued correspondent of "Science-Gossip," again calls attention to the fact that while "smooth" diatoms have been patiently studied with lenses of high resolving power, those with coarse lines or costæ being easy of resolution have escaped such scrutiny, though many of them are possessed of finer markings which are capable of resolution by the means applied to more "difficult" diatoms. The costæ of some species of Synedra and Cymbella he has recently studied in this way, and found the rib-like lines composed of a series of beads, reminding him of peas in a well filled pod. He has not yet been similarly successful with the Pinnularias.

NOTES.

The State Board of Education have presented to the Massachusetts Legislature an extended report relating to the proposed general survey of the state, a subject which was referred to the Board for report by the last legislature. This report makes prominent a number of important points bearing on the necessity of the proposed survey, and gives minute estimates of its cost, which are placed at the comparatively insignificant sum of $25,000 a year for a period of fifteen years. The value of the survey to the people of the state is so very apparent that we have little fear but that the legislature will pass the bill, as soon as it comes before them, notwithstanding the economical wave that in its periodic course has again broken upon our land. Certainly, if we were blessed with a more thorough understanding of our resource, and worked in all departments with more knowledge of the laws of

nature, and did not so ignorantly interfere with laws which we cannot change, we should not so often be in that sad position, when we have to stop and ask, Why are we so poor when riches are under our feet? To this end, that we may know our resources, and not only take better advantage of them, but also through knowledge avoid mistakes, we hold that the thorough survey of the state will prove of lasting benefit, and long before it is finally completed show itself even a financial success.

The survey, as asked for by the original memorial of the American Academy and as endorsed by the State Board of education, is not designed to be simply topographical and geological, though the well known imperfections of all maps of the state show the importance of the former, while the almost total ignorance of our very peculiar geology, and the present excitement at Newburyport, over the discovery of lead and silver, certainly are proof of the importance of the latter topic. But not only are these departments contemplated, but that of biology as well, and here again can we cite the importance of the survey in a field where ignorance is so uniformly the rule that to be wise is considered foolish. Here are thousands of people in the state dependent on the success of their crops and their stock for support, and hundreds of thousands still more dependent on what their farms will bring them, and all, so nearly or entirely ignorant of nature's laws, that hardly an act is committed in the efforts of cultivation, that is not sowing the seeds of failure in the future. It is the bearing which the biological part of the survey will have on these practical and vital points of our daily life, that will in the end make it the most important branch of the survey, though the very ignorance which will be its work to supplant by knowledge, will be the cause of its being the least understood at first, and the hardest to make men realize the importance of providing for, by Legislation.

For our credit as a state ever ready to do that which is best for the people, and from the much higher principle, the advancement of knowledge among men, and the consequent higher degree of general education, we hope and trust that the important matter of a thorough and exhaustive survey in all departments, will not only be provided for by the present Legislature, but will be placed on so firm a basis that no matter what political revolutions may ensue during the next fifteen years, the provisions for the survey shall remain intact.

Three preliminary maps have during the past year been published by Hayden's U. S. Geological Survey of the Territories, the one of most interest being a preliminary map of Central Colorado showing the region surveyed in 1873.

A glance at the "Catalogue of the Publications of the U. S. Geological Survey of the Territories, F. V. Hayden, Geologist in charge, Washington, 1874," may give some idea of the energy shown in the conduct of this survey; several volumes appearing annually, beside smaller pamphlets, containing a large mass of information regarding the public lands. Exchanges of the publications of the survey with societies and individuals engaged in scientific studies are desired.

PROF. CH. FRED. HARTT, who left this country for Brazil by way of England in Oct. last with his assistant and photographer, Mr. John Branner of the Geological Laboratory, Cornell University, was busy on the surface geology of the neighborhood of Rio de Janeiro when last heard from. We believe he has found reasons to differ from Prof. T. Sterry Hunt's views in regard to the origin of the loose materials covering the rocks around Rio. He has been going over the ground with great care, working it up in detail, and we shall expect an interesting communication from him on the subject as soon as he returns.

SIR WILLIAM JARDINE died Nov. 12 at the age of seventy-four. Though especially devoted to ornithology, he established the "Magazine of Zoology and Botany," afterwards the "Annals of Natural History," which in 1841 was combined with the Magazine of Natural History to form the "Annals and Magazine of Natural History," now the leading English journal in this department of science.

VALUABLE sets of Floridan plants have been made by Dr. G. Palmer, and are authentically named and for sale at the herbarium of the Botanic Garden at Cambridge. They can be purchased on application to Prof. A. Gray, as Dr. P. is now in California.

MR. F. W. PUTNAM has received the appointment of Curator of the Peabody Museum of American Archæology and Ethnology at Cambridge, held by the late Professor Wyman.

THE Governor of Rhode Island has recommended, in his inaugural address, a geological survey of that state.

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RED SNOW.

BY F. C. CLARK, M.D.

Perhaps no more curious phenomenon meets the gaze of the Arctic observer than what is familiarly known as "red snow;" and truly a beautiful sight must the little plant present, in direct contrast with the expanse of white, whether appearing in thinly scattered patches, or crimsoning the hills and plains for miles around.

The subject has ever been of the deepest interest, and excited the attention of the most eminent scientists. For a long time its true place in nature remained undetermined. On each side of the contest as to its affinities were arrayed most distinguished authorities, each claiming to have solved the mystery. Yet it was only after many conflicting opinions that its true position was determined. Hence if the vegetable origin of "red snow" seems conclusive enough to us, we must not forget the advantages we possess over former observers. The microscope, the natural sciences and mechanics, have all received marked improvement since the first discovery of the snow plant.

The history of the *Protococcus nivalis*, as named by Agardh, dates from a very early period in antiquity. Aristotle tells us it was known in his time. In fact it was one of the chief objects which attracted the attention of mountain travellers and of adventurers in the frozen regions of the North.

But the most accurate accounts extant only date from 1760 of the present era. Saussure about this time made careful examinations of "red snow" obtained from the Apennines. The result of his investigations was the discovery of a vegetable substance which he supposed was the pollen of some plant.

The subject now remained quiescent until the return of the Arctic exploring expedition under Sir John Ross in 1819. New material was now obtained for examination. Specimens of "red snow" were sent to Robert Brown and Francis Bauer.

Brown gave it as his opinion that the snow plant was a unicellular plant belonging to the order of Algæ.

Bauer, however, dissented from Brown, and declared it to be a species of fungus (*Uredo nivalis*). Apart from his conclusions upon the subject, he made many interesting experiments with the plant. Its microscopical appearances and also analysis were given. But perhaps the most curious experiment was his attempts at propagating the Protococcus.

For this purpose he placed some of the "red snow" given him by Sir John Ross, and which had already become white from long exposure to the air, in a glass vessel filled with snow, taking care to mix the two well together; on exposing the vessel of snow in the open air for some time, and, fortunately, while the weather was unusually cold (in December), he found the snow to change from white to pink; and finally to regain its original color, and its quantity also to increase.

Not satisfied with this, he carried his investigations still further. He put a small quantity of the snow plant upon the surface of some snow, and watched the result. The temperature being sufficiently low, the same changes were observed as occurred in the former instance, but a greater increase in bulk of the plant.

From these experiments Bauer concluded that the young plant became green before it matured; that a certain degree of cold was necessary for its production, and that, if exposed to the open air alone for some days, the plant would lose its red color.[1]

In 1823 Baron Wrangel after careful analysis denied the conclusions arrived at by former observers, and pronounced the plant to belong to the lichens, naming it *Leprasia Kermesina*. So in-

[1] Philosophical Transactions, 1820, Part 1, pp. 165–174.
"Microscopical observations on Red Snow, by F. Bauer. Journal of Sci. and Arts (Royal Inst. of Gr. Br.), vol. vii, 1819."

stead of clearing away all doubts he only served to introduce new matter for discussion.[2]

Two years afterwards the question was again agitated by Agardh and Dr. Greville[3] of Edinburgh. Both these observers agreed in every particular with Robert Brown. Sir William Hooker also, the eminent naturalist and botanist, later confirmed the views of Agardh and Greville; but he named the "red snow" *Palmella* instead of *Protococcus nivalis* Agardh. The algic nature of the plant was thus decided for a time.

During the year 1838 several observers on the continent, among whom may be mentioned Kunze, Unger and Martius, wrote elaborate monographs upon the subject, but without eliciting anything new.

Thus far we have had to do only with believers in the vegetable origin of the Protococcus. There are almost as many eminent observers arrayed on the opposite side, who pronounce in regard to its animal nature.

In August, 1839, Mr. Shuttleworth,[4] an English resident of Switzerland, understanding that "red snow" had been discovered in the vicinity, betook himself thither, and by the aid of his microscope was enabled to make out the presence of animalcules. Adding to these examinations he described two species of low animal organisms, and proclaimed the animal nature of the snow plant.

In 1840, Professor Agassiz of Neufchatel made a tour to the glacier of Aar, and discovering "red snow" there, carefully examined it with a microscope, and presented his views concerning the plant before the British Association at Glasgow. Not only did he fully confirm the conclusions of Shuttleworth, but he added four other species of animalcules to those already discovered and described by Shuttleworth. Agassiz considered that the opinions of former observers were due to their mistaking the *ova* of animalcules for the spores of a plant.[5]

After the confusion necessarily arising from such a variety of

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[2] Penny Encyclopedia.

[3] "Scottish Cryptogamic Flora," by Robert K. Greville. Edinb., 1825–1829. Vol. iv, p. 231.

[4] "Nouvelles observations sur la matière colorante de la neige rouge," par James Shuttleworth. Bibl. Univ. xxv, 1840. Edinb., New Phil. Journ., xxix, 1840. Froriep. Notizen, xvi, 1840. Also Bibl. Univ. xxv, 1840. Edinb. New Phil. Journ. xxix, 1840.

[5] *Loc. cit.*

opinions, and each advocated by unimpeachable authorities, had somewhat subsided, the true nature of the Protococcus was at length decided. And to-day its vegetable origin is no longer doubted. It holds no middle place between the animal and the vegetable, as some have thought, nor is it even a low animal organism; but in every sense of the word an alga, as Brown, Agardh, Greville, Hooker, and many other eminent authorities have since declared.[6]

Animal substances, it is true, are found present in the alga. But this is easily accounted for when we consider the immense numbers of low animal, as well as vegetable organisms, floating in the atmosphere, and even in the most frigid of climates.[7]

Mineral substances are also present, thus misleading the chemist as well as botanist and naturalist. Hence analyses of the snow plant often strengthen the observer's private opinions, thus rendering a bias of judgment almost unavoidable.

Botanists refer the snow plant to the family *Palmellaceæ*, the lowest of plants, and related to the *Confervaceæ*. It is propagated like all the members of this family, by a kind of gemmation. A tube-like process shoots out from the plant dilating at the extremity. Gradually a cell is formed at the end of the tube, which continues contracting until the new cells lose all connection with the mother-plant, and become distinct individuals.

In some species of this family true segmentation is the rule. In this mode of reproduction the young plants exhibit for a short time remarkable powers of locomotion, which are due to the rapid vibration of an immense number of cilia. When this motion ceases, then is the signal for segmentation or reproduction to begin. When segmentation ceases, motion reëstablishes itself, then segmentation recommences, and so on.[8]

The vibration of these cilia has undoubtedly led observers, opposed to the vegetable origin of Protococcus, to regard it as similar to the zoospores of certain Protozoa. For it is a well-known fact that "red snow" possesses some degree of motion.

The Protococcus is very minute, in fact microscopical. Under the microscope it has the appearance of brilliant garnet-colored

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[6] Brand's Dict.. of Sci. Lit. and Art.

[7] Kane's Narrative, 1854. pp. 138–140.

[8] Chamber's Encyc. *vid.* Palmellaceæ. (See also Clark's "Mind in Nature" for original observations on American specimens by this eminent observer, illustrated by figures.—Eds.)

disks resting upon a matrix of gelatinous matter. They resemble to a remarkable degree the red globules of the blood in size and color. But Bauer gave their size as $\frac{1}{1200}$ inch in diameter; whereas more careful measurement will show the diameter of the disks to be nearer $\frac{1}{3500}$ or $\frac{1}{4000}$ inches. Each one of these globules is made up of seven or eight cells filled with a liquid, which probably contains the coloring matter of the Protococcus. But Brocklesby thinks the liquid contains great numbers of animalcules.[9]

Bauer, Wollaston, DeCandolle, Hooker, Peschier and others give chemical analyses of the snow. But as they all give nearly like results, the analysis of Peschier is only subjoined, viz.:

Silicious matter	66.50
Alumina	6.35
Peroxide of iron	21.35
Lime	1.17
Organic matter	6.80[10]

The "starch test" proves the vegetable origin of Protococcus perhaps better than any other.

The genus to which the snow plant belongs takes a variety of forms; of dust-like particles, as in the case of "red snow;" of a stringy gelatinous mass as in "gory dew;" or of a thin and membranous structure, like a frond.

Dr. Kane found the color to be of a dark red. On paper it produced a cherry red stain, which became brown on exposure to the air. Its solution in water, in which red snow is very soluble, is of a muddy claret color. But if the snow were damp, upon which it was found, the snow beneath was stained a beautiful pink.[11]

The Protococcus is found above 83° north latitude, and as far south as in New Shetland in 70° S. Lat. Sir John Ross saw it extend over the cliffs bordering upon Baffin's Bay for a distance of eight miles, and, in some instances, to a depth of twelve feet. To this day the heights are called the "Crimson Cliffs."[12]

Parry found "red snow" even far from land upon the ice-fields of Spitzbergen. Kane obtained it fifty miles from land upon the floes of ice. Here it seems to have been diffused through the

[9] Brocklesby's Meteorology, pp. 120–121.
[10] Penny Encyclopedia.
[11] Kane's Narrative, 1851, 1854. pp. 138–140.
[12] Kane's Narrative.

atmosphere over the Arctic snows like other organic matter. Kane also found it mixed with foreign vegetable matters, which might perhaps be the source of the ammonia necessary for its existence. Indeed the snow plant was always of a deeper red, and in a more flourishing condition in proportion to the quantity of this extraneous matter.[13]

This alga is found also upon the tops of high mountains above the snow-line. It has long been known to exist in the Apennines and Pyrenees Mountains. The recent discovery of the snow plant in our own country (in California) upon the tops of the Sierra Nevadas, at an altitude of 10,000 feet above the level of the sea,[14] renders the subject under discussion of twofold interest. Specimens obtained from this locality show the same structure and microscopical appearances as those from other parts of the world.

Damp places, near the ocean or fresh water, seem to favor its production. The specimens supplied to Dr. Greville were from the shores of Lismore, off Scotland. It was found upon reeds and stones, but grew to perfection upon calcareous rocks.[15]

A species of alga (*Uredo viridis*) of a greenish color has been described. But Martius refers it to the *Protococcus nivalis*, though in a different stage of development.

Other varieties of colored snow have been mentioned, which are confounded with Protococcus. What is known as "brown snow" is due to a discoloration of the snow by earthy matters washed down by mountain streams. Arctic observers (Belcher) speak of a red snow produced by a species of little auk which feeds on shrimp and congregate there in immense numbers.

Snow and ice often appear colored from reflection. These illusory appearances are easily explained. Dr. Kane speaks of "red ice" which, on a nearer inspection, proved to owe its red color to reflection. The same observer mentions "blue ice" as being sometimes seen, and due to like causes.[16]

But apart from all this, the Protococcus declares its vegetable

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[13] Kane's Narrative.

[14] It was also discovered at an elevation of 6,500 feet on the Cascade Range in Washington Territory by the late George Gibbs. See NATURALIST, v, p. 116, 1871. — EDS.

Red snow is not seldom found among the Sierras, in the so-called Alpine regions; in Clover Mountains, East Humboldt, Nevada and the Uintahs, from July to September. It is found upon old snow drifts (vid. U. S. Geol. Explor. of 40th parallel, vol. v, Botany, 1871. Page 415, Prof. H. C. Woods).

[15] Penny Encyclopedia.

[16] Kane's Narrative, pp. 138–140.

origin. And yet, why it should prefer to make the snow its habitat, or how it can find its way into those regions of frost and infertility, remains a question which still perplexes the naturalist and philosopher.

THE SISCO OF LAKE TIPPECANOE.

BY PROF. D. S. JORDAN.

A SHORT time since, I received from Prof. E. T. Cox, state geologist of Indiana, a collection of deep-water "Siscoes" taken in Lake Tippecanoe, Kosciusko Co., Indiana, by Judge J. H. Carpenter of Warsaw. Prof. Cox requested me to examine these fishes, and prepare an account of their characters and relationship, as considerable interest is attached to them as well as to the fauna in general of the "bottomless lakes" of northern Indiana.

I find them to be Salmonoids belonging to the genus Argyrosomus of Agassiz, a group closely allied to the white fishes (Coregonus) but distinguished by the greater development of the lower jaw, which usually projects decidedly beyond the upper, the reverse being true of Coregonus. The maxillary bones are rather longer, and the bones of the mandible rather heavier, and the teeth although very feeble are slightly stronger than in Coregonus. Compared with Coregonus most of the species have a more slender form; hence their popular name of "lake herrings," although their resemblance to the sea herring is quite superficial.

This Indiana Argyrosomus appears to be quite distinct from the species found in Lake Michigan; *i. e.*, the shallow-water "herring" (*A. clupeiformis* Mitch.) and the deep-water "moon eye" (*A. Hoyi* Gill) and "black fin" (*A. nigripennis* Gill), and it is presumably different from *A. harengus* (Rich.) and *A. lucidus* (Rich.), which, if really distinct species, seem to be loose-scaled, shallow-water fishes, allied to *A. clupeiformis*.

It seems to be identical with the "Sisco" of the deep lakes of southern Wisconsin, a fish, which, although known for some time to naturalists, has not yet, as far as I am able to ascertain, received any specific name.

I have therefore ventured to describe these fishes as new, under

the name *Argyrosomus Sisco*,[1] taking as the type of the species several specimens — male and female — from Lake Tippecanoe, caught in the spawning season, about Nov. 25, 1874. Comparisons with *A. Hoyi* and other related species are made below. I am indebted to Dr. Hoy for specimens of *A. Hoyi* and the Wisconsin "Sisco," and for the opinion that the latter is entirely distinct from *A. nigripennis*, a species which I have been unable to obtain.

This fish has been found in Geneva Lake in Walworth Co., Lake Mendota in Dane Co., and, I think, in Lake Koshkonong. It should be noticed that these lakes belong to different water systems, Geneva Lake being drained by Fox River, a tributary of the Illinois, Lake Mendota by Cat-fish River, a branch of Rock

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[1] ARGYROSOMUS SISCO Jordan.—Form regular, spindle-shaped, compressed, slightly elevated at the beginning of the dorsal fin; general outline not very different from others in the genus.

The greatest depth of the body is contained 4 1-10 times (4 1-4 in males, 4 1-2 in *A. Hoyi)*, in length from tip of snout to the end of the scales at base of caudal. The thickness of the body is about half its depth. The head is moderate, pointed, compressed and depressed. The skull is flattish above, with a longitudinal ridge. The interorbital space is slightly wider than the eye. The length of the head is less than the height of the body (nearly equal in males), and is contained 4 1-2 times (4 1-3 to 5; 4 in *A. Hoyi*) in length of body exclusive of caudal. The eyes are large and circular, and their diameter is contained 3 3-5 (3 1-2 to 3 3-4; 3 1-2 in *A. Hoyi)* times in the length of the side of the head. The nostrils are large, nearly midway between eye and tip of snout, and on the upper surface of the head.

The opening of the mouth is rather small and quadrangular. The lower jaw is longer than the upper, rather less so than in *A. clupeiformis*, very much more so than in *A. Hoyi*, which is almost Coregonus-like in this respect. A slight elevation at the tip of the lower jaw, suggesting the "nail" on the bill of ducks, overlaps and fits into a slight emargination at the end of the upper jaw. Margins of lower jaw with slight roughnesses representing teeth. Intermaxillaries with minute asperities. Tongue provided with minute teeth which however are readily evident.

Maxillaries rather strong, weaker than in *A. Hoyi*, contained 3 1-3 (2 3-4 in *A. Hoyi)* times in side of head, not reaching a vertical line through the centre of the eye.

Length of mandible much more than least depth of tail. 2 1-8 (2 in *A. Hoyi)* times in head. General characters of opercular bones, branchial openings and branchiostegals as in other species.

Distance from occiput to tip of snout contained 2 1-3 times (1 7-8 in *A. Hoyi)* in distance from occiput to beginning of dorsal. Depth of head at occiput 2-3 the length of the side of head.

The scales are relatively smaller than in most of the other species, the lateral line having 84 developed scales (81 to 86; 75 in *A. Hoyi*, 73 in a specimen of *A. clupeiformis)* besides several small ones at the base of the caudal, which form a concave margin somewhat parallel with the fork of the fin, as in other species.

The scales, though thin, are quite firm, rather less so than in *A. Hoyi*, very much more so than in the "Lake Herring."

The lateral line is very evident, nearly straight, and rather nearer the back than belly. There are eight series of scales between the lateral line and the ventrals.

The radial formula is D. II, 9 or 10, P. 15, V. 12, A. I, 12.

The dorsal fin begins in front of the ventrals at a point about equidistant between the front margin of the eye and the first rays of caudal. It is short and rather high;

River, while Lake Tippecanoe is one of the sources of Tippecanoe River, which flows into the Wabash. I have not heard of these fishes in Lake Winnebago or any water flowing into Lake Michigan. In Lakes Winnebago and Buttes des Morts the name "Sisco" has been transferred to the common white lake bass (*Roccus chrysops* Gill).

Concerning the habits of the Indiana Sisco, we have the following information from Judge Carpenter:

"Some years ago, probably five, these fish were discovered on the north side of Tippecanoe Lake by Isaac Johnson, and at each return of their spawning season, which is in the last of November, they have reappeared in large numbers. They are not seen at any other season of the year, keeping themselves in the deep water

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its greatest height is a little more than 2-3 the length of the head. Its length is 2-3 of its greatest height. Its longest ray is a little more than 3 times the length of the shortest, thus giving the fish a different form from *A. Hoyi*, in which the longest ray of the dorsal is nearly 4 times the length of the shortest. The adipose fin is rather slender and reaches slightly beyond the termination of the anal.

The pectorals are rather long and pointed, about as long as the ventrals and of course not reaching nearly to them.

The ventrals are rather large, more than 2-3 the length of the head, falling considerably short of vent. The accessory scale at their base is rather short and triangular, less than half the length of the fin. The depth of the body at the vent is contained 5 3-4 (6 3-4 in *A. Hoyi*) times in the length of the body.

The caudal fin is deeply forked, its lobes are long and pointed, but in all my specimens more or less mutilated. The distance from the vent to the rudimentary caudal rays is contained 4 3-5 (4 1-2 in *A. Hoyi*) in the length of the fish.

The color (from fresh specimens), deep steel-blue above becoming gradually paler to below the lateral line, where it changes to silvery. The arrangement of the scales gives an appearance of longitudinal lines which are conspicuous in certain lights.

All the scales except those of the belly are finely dotted with black, except on their free margins, which being transparent, show the dots on the scales below.

Vertical fins and tips of paired fins also thickly punctate, as well as the skin of the head, particularly above and on the maxillaries and suborbitals.

These black dots seem to be of specific importance as they occur in both Wisconsin and Indiana specimens. They are not noticeable on *A. Hoyi*, excepting on the head. The latter is a more brilliantly colored fish, its scales having a peculiar rich silvery lustre wanting in the Sisco.

Average length of specimens examined, 9 1-2 inches, including the caudal fin, being thus larger than *A. Hoyi*, which rarely exceeds 7. The largest specimen of the Sisco seen measures 10 1-2 inches. Larger individuals sometimes occur. Mr. Carpenter writes that "occasionally one is caught weighing 1 1-2 to 2 pounds, but it is very unusual to find them so large."

The single specimen in my possession of the Wisconsin Sisco agrees in the main with the above, but it is a slimmer fish (perhaps owing to sex or season), the depth being contained 5 times in the length of the body, the head 4 2-3 and the eye 4 times in the head. The maxillary is longer, 2 7-8 in length of head, the depth at the vent 6 3-4 in the length of the body, and the distance from vent to base of caudal only 4 times. The scales are obviously larger, there being but 77 in the course of the lateral line. To how much weight these differences are entitled can only be told by a comparison of a number of specimens.

of the lakes. The general opinion is that they will not bite at a hook, but Mr. Johnson says that he has on one or two occasions caught them with a hook. To my knowledge they have never been found in but two of our lakes, Tippecanoe and Barber's, which are both large lakes and close together, as will be seen by reference to the map.

The spawning season lasts about two weeks and they come in myriads into the streams which enter the lakes. There are large numbers of persons who are engaged night and day taking them with small dip nets. They are caught in quantities that would surprise you, could you witness it. Those who live in the neighborhood put up large quantities of them, they being the only fish caught in the lakes that will bear salting. Some gentlemen who have been fishing to-day (Dec. 8) inform me that the run is abating and that in a few days the fishes will have taken their departure for the deep water of the lakes, and will be seen no more until next November."

As far as I can learn, the habits of the Wisconsin Sisco are similar, but they seem to be much less abundant. Fishermen say that specimens were once sent to Prof. Agassiz, who pronounced them something "new and extremely rare." Specimens procured for me last year, by Prof. Copeland, cost a dollar apiece of the fisherman, which shows the high value attached to these fishes, as *A. clupeiformis* when taken from the nets is not worth more than ten cents a dozen.

Concerning the Lake Michigan species Dr. Hoy writes me, "*A. nigripennis* is a large, magnificent fish. It can be known at once by the black fins. It is never caught in less than 60 fathoms, and not in large numbers till you reach a depth of 70 fathoms. The *A. Hoyi* is the smallest of the Salmonidæ, if I am not mistaken. It never approaches the shoal water, where *A. Artedi* (= *A. clupeiformis*) is only found. About 30 or 40 fathoms is as near shore as it has ever been captured here."

BOTANICAL OBSERVATIONS IN SOUTHERN UTAH. II.

BY DR. C. C. PARRY.

On the 8th of May an opportunity offered of making an excursion in a southwestern direction to the Beaver-dam Mountains, about twenty miles from St. George. This range forms a high dividing ridge extending in a southeast course, separating the valleys of the Santa Clara and Muddy Rivers, which are the principal northeastern tributaries to the Rio Virgen. Through this mountain mass, composed of variously inclined sedimentary rocks made up of alternate strata of sandstone, limestone, and variegated marls, with immense beds of gypsum, the main stream of the Virgen cleaves its way by an impassable cañon. Our route after crossing the Santa Clara near its mouth, then flooded with melted snow and turbid from the dissolved mud of its lower alluvial banks, followed up one of the "dry washes," as they are significantly termed, leading more directly towards the mountain slope. Along the course of this sandy bed, the "desert flowering willow" (*Chilopsis linearis*) was abundant, though not yet fully leaved out, nor offering any display of its showy Catalpa-like blossoms. Still more conspicuous at this season of the year was the *Cowania Mexicana*, then completely covered with a profusion of pure white flowers, almost hiding from view its finely divided varnished leaves. A pleasant balsamic fragrance, exhaled in the clear atmosphere from this charming shrub, lent additional attractions which seemed to be appreciated by a swarm of hovering insects. The adjoining uplands were composed of various colored clay and sandy knolls, often fantastically washed, and intersected by miniature ravines and deep basins. The vegetation on these slopes was mainly composed of the prevalent Chenopodiaceæ, occasionally set off by the more graceful forms of Larrea, Algarobia, or the showy *Dalea Johnsoni*. Amid the more usual forms of undergrowth, made familiar in my rambles near St. George, my attention was drawn at a single locality to a showy Papaveraceous plant, with nodding white flowers, in which I was delighted to recognize the *Arctomecon Californicum* Torr. (No. 6), collected only by Fremont thirty years ago, and figured and described in his report from a

single specimen. The present collection, since supplemented by mature fruiting specimens, furnishes the means of completing the description of this interesting plant, which seems to differ from the original figure in its less hairy leaves, four (not six) valved capsule and more cæspitose habit. The fruiting specimens show marcescent petals, persisting after the maturity of the seed, and an eversion of the upper third of the triangular valves, leaving the placental ribs connected at the summit with the united stigmas and forming a basket in which the shining black seeds lie loosely like so many eggs. The plant is apparently biennial, with deep tap roots, the broken stem and leaves giving out a yellowish sap. In the two localities where found it grew in a loose marly soil, strongly impregnated with gypsum.

On reaching a higher elevation on a continuous upward grade there was brought to view a greater profusion of plants and shrubbery, conspicuous among which may be noted *Audibertia incana*, *Coleogyne ramosissima*, and a cæspitose yellow-flowered Mamillaria (*M. chlorantha* Engel., ined.). At our nooning place, having reached an elevation of not less than one thousand feet above the valley of the Virgen, a deep gorge in the limestone rocks afforded a scant supply of water. In the abrupt face of these perpendicular rocks, a delicate fern was noticed, which Prof. Eaton has determined to be identical with the *Notholæna tenera* Gillies, from the South American Andes, not before found in North America. Owing to the shortness of our stay and the difficulty of securing specimens from the inaccessible positions in which they grew, only scanty collections were made, but the locality is so readily identified that some future botanist will be able to supply the demand for this interesting addition to North American Filices. Other plants afforded by this locality were the diminutive *Œnothera pterosperma* Watson (No. 70), *Astragalus arrectus* (No. 45), a tall Phacelia of a climbing habit with foliage resembling *P. tanacetifolia*, but apparently distinct, *Phacelia ramosissima* Benth. (No. 184) and a robust showy form of *Eriogonum ovalifolium* Nutt. (No. 241).

Farther on in our upward ascent, we reach a growth of clumpy cedars, being the common species of this country, extending from Lake Utah to Arizona. This is the *Juniperus tetragona*, var. *osteosperma* Torr., since determined by Dr. Engelmann to be a variety (*Utahensis* ined.) of the western species, *Juniperus Californica.*

It is readily distinguished from the more common *Juniperus occidentalis* Hook., with which it is probably associated farther south, by its larger green mealy-coated fruit, one-seeded, with a hard stony shell, the mature fruit fading chocolate-brown, not purple, etc. With this tree at all high elevations the common "Piñon" (*Pinus edulis* Engel.) is quite constantly associated. The undergrowth here exhibits less of a desert feature in the presence of such plants as *Streptanthus cordatus* Nutt. (No. 10), *Pentstemon puniceus*, var. (No. 152), *Phlox canescens* Torr. & Gray (No. 186), *Eritrichium leucophœum* DC. (No. 166). Quite a conspicuous feature in the floral landscape was presented by dense clumps of *Berberis Fremontii* Torr. (No. 5), then in full flower, its bright yellow racemes contrasting prettily with its stiff spiny holly-like leaves.

Near the close of the day in ascending the last sloping ridge, leading down on the opposite side to the wide desert plain through which the Muddy courses to unite with the Virgen, we first recognized one of the principal objects of our journey in the singular forms of that remarkable desert production, *Yucca brevifolia* Engel. This is universally known among the Mormon settlers under the name of "*The Joshua.*" The mail rider over these desert tracts had furnished us weekly reports of its progress in flowering, so that we were constantly on the lookout for a first view of what had never yet been examined by a scientific botanist. At first a few scattering clumps of the peculiar stiff spiny leaves that characterize this genus of plants attracted attention, then some gaunt forms raised on withered trunks revealed the identical species. On hastening forward to a more vigorous growth, where the masses of compact flowers were visible at a distance crowning the top of the upper branches or main axis, we soon had one of the lower flowering stems ruthlessly torn down for a closer inspection. The first feeling was one of disappointment; the flowers, crowded in a close pyramidal head, failed to exhibit the ordinary graceful forms pertaining to the Liliaceæ. The perianth was of a dull greenish-white color, its divisions long-linear, thickened and confusedly massed together, while the odor given out was decidedly fœtid, seeming to present special attractions only to various beetles and insect larvæ. An examination of the inflorescence shows a regularity such as the botanist would expect: the upper leaves of the flowering branch gradually becoming bract-form subtend in their axils small jointed flower-stems, with the lower flowers generally

arranged in threes. These in continuing their spiral arrangement on the main axis form the condensed mass of flowers which, opening from below upwards, prolong the flowering process for several weeks. Only a few of the flowering stems perfect fruit, and occasionally (as during the present season) all prove abortive, possibly owing to the absence of some insect agency for effecting fertilization. In the desert districts lower down, where this species especially flourishes, the flowering heads are said to weigh frequently over fifty pounds.

The material and notes now supplied will, it is hoped, enable Dr. Engelmann who has made a special study of this genus, to complete the technical description of this remarkable species.

A short ramble on the following morning in the vicinity of our camp brought to view some other points of botanical interest. Quite common on loose gravelly slopes occurred the neat species of Ranunculus, *R. Andersonii*, Gray (No. 2). This differs from the figure and description in Watson's Bot. King's Exp., in its constant branching habit, rendering this variety better suited for horticultural purposes. Its marcescent petals seem to retain to some extent their bright color and streaks after the maturity of the achenia.

Here also were found the singular Rutaceous shrub, *Glossopetalon spinescens* Gray (No. 27), and *Spiræa Millefolium* Torr., which closely simulates *Chamæbatia foliolosa* Benth. Along the edges of dry ravines *Astragalus eriocarpus* Watson (No. 44) was quite frequent, usually associated with *Eritrichium leucophæum* DC. (No. 166) and the handsome *Pentstemon puniceus* Gray (No. 152). On the summit of a high limestone ridge overlooking the valley of the Muddy, was seen for the first time the dwarf species of Agave, *A. Utahensis* Engel. This species, which adheres quite closely to crevices in the limestone rocks, forms extensive patches by sending out offsets, so that in cultivation it could be readily propagated, making an interesting addition to the class of hardy pot plants. At the time of our visit it was just sending up its flowering stalks, too early, however, for securing herbarium specimens, which had been supplied in the collections of Dr. Palmer four years previous, from which the original description was drawn.

The hasty return trip to St. George, loaded down with Yuccas, Cacti, and Agaves, did not afford much opportunity for excursive botanizing.

With the advent of prolonged summer heat the Eriogoneæ became especially prevalent both in variety of species and number of individual forms. Thus with the exception of Nemacaulis and Lastarriæa (the latter probably lately introduced into California from Chili), we have representatives of all the North American genera of the tribe. Of these, Eriogonum includes eleven species, Chorizanthe two, Oxytheca, Centrostegia and Pterostegia, one each. Of the slender annual species of Eriogonum some are remarkably gregarious in their mode of growth, forming dense patches that give a singular aspect to the bare landscape. This is particularly marked in *E. reniforme* Torr. (No. 237) and *E. trichopodum* Torr. (No. 240). More irregularly scattered over rocky slopes occurs the singular fistulous-stemmed species *Eriogonum inflatum* Torr. (No. 230); this from the peculiar bulging appearance of its main stalk and upper branches, sometimes fully one inch in diameter, has received the fanciful popular name of "bottle stoppers." Early in the season the young and tender shoots afford an agreeable sub-acid juice not unwelcome to the thirsty traveller over these arid tracts, in lack of more attractive cheer suggested by the above popular name. Later in the season *E. Parryi* Gray, n. sp. (No. 239), with its broad cordate leaves and divaricately branching flower stem, is commonly met with on rocky slopes, being usually associated with *Chorizanthe brevicornu* Torr. (No. 230) and *Chorizanthe rigida* Torr. (No. 231). On dry sandstone rocks, *Eriogonum racemosum* Nutt. (No. 234) is conspicuous, and in favorable localities there is an abundance of the singular *Oxytheca perfoliata* Torr. & Gray (No. 228) and *Centrostegia Thurberi* Gray (No 232).

Not infrequent in the shade of overhanging rocks adjoining the Virgen is a very neat species of Symphoricarpus recently described by Professor Gray under the name of *S. longiflorus* (No. 87). This shrub forming dense clumpy masses, with slender branches, small foliage, and delicate white flowers streaked with pink, would make an interesting addition to this class of common cultivated shrubs; unfortunately the flowering season was too late to secure mature fruit to determine its scientific characters or make it available for garden cultivation. Quite constantly associated with the above is a slender-leaved suffruticose Arenaria, *A. Fendleri*, var. *glabrescens* Watson (No. 20), which from its peculiar habit and mode of growth it is difficult to regard as a mere variety of that widely spread subalpine species.

Among the rarities of this section must be noted a well marked new species of the peculiar southwestern genus Petalonyx, characterized by Prof. Gray as *P. Parryi* n. sp. (No. 75), this making a second recent addition to the genus. Of this only a single plant was met with, forming a low bush with remains of dead stalks, especially conspicuous at a distance from the faded leaves of the previous season's growth, exhibiting a pure pearly white. The delicate cream-colored blossoms, with exserted style and stamens, reminded one of Lonicera, but the polypetalous flowers and the peculiar hairy brittle leaves designated it at once as belonging to the Loasaceæ. A diligent search over the dry gravelly and alkaline soil, where it was found associated with the common "grease woods" of this region, failed to bring to light any other plants, so that this single locality, precariously situated within a stone's throw of the great Mormon temple, does not encourage the hope of a prolonged existence for the benefit of future botanists.

Another interesting plant of this same family was also met with in crevices of denuded sandstone rocks near the Santa Clara. This I recognized at once as an old acquaintance, having several years previously collected imperfect specimens of the same, past flowering, on the Lower Colorado. Of this, provisionally named in a manuscript list *Eucnide urens* Parry, full material has now been collected, from which Prof. Gray has recently published a description in the Proceedings of the American Academy, Vol. x, pp. 71–72, under the name *Mentzelia* (*Eucnide*) *urens*, n. sp. (No. 79).

Another plant especially worthy of notice belongs to the natural order *Asclepiadaceæ*. It is a small twining milk-weed, growing in loose drifting sand, in which the thick tap roots are deeply buried; these send up several slender stems, which cling to the scanty shrubbery or lie prostrate on the scorching sand, where blown about by the wind they form irregular and constantly changing circles. The small umbels of flowers in the axils of the upper leaves are of a dull yellow color and are without the usual horny appendages. Dr. Engelmann, to whom specimens have been sent, has characterized it in the accompanying list under the name of *Astephanus Utahensis*, n. sp. (No. 209).

A frequent associate of this latter plant is the little known *Dicoria canescens* Gray, an annual composite plant allied to Franseria. In similar dry sandy soil was also found *Franseria eriocentra* Gray, forming an irregularly branched bushy shrub two to three feet in height.

With the disappearance of the ordinary class of desert annuals, the early summer rains bring forward a peculiar set of composite plants, remarkable for their strong odor, due to a large development of oil-bearing glands. These include two species of Psathyrotes, viz., *P. annua* Gray (No. 114) and *P. ramosissima* Gray (No. 115). Besides these is a plant not seen by me, probably a Pectis, which spreads over the ground in prostrate mats, its foliage so strongly charged with an aromatic oil that it is extracted by a rough process of distilling for domestic use, the plant receiving the popular name of "head-ache weed." Later in the season my attention was mainly taken up in the collection of seeds. This though generally tedious and uninteresting, especially when requiring exposure to the hot mid-day sun, yet offered not a few points of peculiar attraction. It was instructive in passing over these arid tracts to note the provision made for scattering or preserving these necessary products for the succeeding season's growth. Thus the evanescent annuals drop their seeds in the loose sandy or gravelly soil or rock crevices, in the most suitable conditions for retaining their vitality during the hot dry season, while the withered stems, having fulfilled their part in the processes of growth and reproduction, dry up and are blown away. Deep sun-cracks in the strongly impregnated gypseous soil receive the seed of the future crop of annual Œnotheras, Gilias, Phacelias and Eriogonums, to be covered up by the first rains. The species of Compositæ, not so generally here as elsewhere provided with a feathery pappus for transporting their seeds, maintain their foothold by unusual productiveness. Even in the case of *Glyptopleura setulosa* Gray, which seems amply furnished with a light capillary pappus, it is rare to find the aigrette expanded, and the matured achenia remain enclosed in the involucre, thus leaving them to be planted in the loose soil with the dried-up remains of the parent stem. Another instructive example is presented by *Tetradymia spinosa* H. & A., in which the seeds are wholly covered with a white woolly down, and at the season of maturity are thickly scattered over the arid tracts in which it grows, gathered by the wind like snow drifts, into every sheltered nook, or clinging to the adhesive hairs of branching Mentzelias.

Bulbous plants, such as Androstephium and Calochortus, hide their newly formed bulbs in the gravelly soil at depths practically inaccessible to all but curious botanists or hungry Indians. A

singular arrangement for shooting seeds was brought to my attention in the case of *Gilia setosissima* Gray. Wishing to collect somewhat largely of the seeds of this neat little annual, I watched more closely than usual the maturity of the capsules. In most of the other species of this prevalent genus, there is a succession of flowers and maturing capsules, which latter opening at the summit discharge their seeds while the plant is still producing flowers, thus rendering it difficult to secure a large quantity of seed without including capsules not sufficiently mature. But in the case of *Gilia setosissima*, all the capsules remain tightly closed till the whole plant becomes dry and brittle. In then gathering seed by picking each plant separately, I noticed the seed projected with some force against my hand. On closer examination I found that these capsules open from below upwards, and that the tension accumulated by the shrinking of the tissues in the process of drying gives an elastic spring to the three separating valves when released from their attachment at the base of the calyx, that throws the contained seed from two to six feet. After making this discovery it was interesting to watch the process by loosening the attachment of the valves with the point of a knife, and see how far they would shoot. The majority of the seeds were scattered within a radius of two feet, while in the plumper capsules the shots took effect to a distance of six feet or more. The three separated valves of the capsules on account of their light chaffy texture were not thrown as far as the seeds.

A similar character, though less marked, was also exhibited in certain species of cæspitose Phlox, though in this latter case the explosions observed occurred some time after the capsules were detached from the calyx. The conclusion arrived at is that the character of explosive capsules in this particular family is peculiar to those that open at the base instead of the summit.

In the succeeding paper I shall conclude this account of botanical observations in Southern Utah by a notice of a short excursion to the alpine district of Pine Mountain, and a more prolonged stay in the vicinity of Cedar City, including a visit to the elevated sheep pasture in the adjoining mountain range,—to be followed by an appendix containing a full list of the plants collected, with descriptions of the new or imperfectly known species.

THE PRAIRIE GOPHER.

BY DR. ELLIOTT COUES, U.S.A.

THE subject of the present history is one of a large group of small quadrupeds inhabiting the western half of North America, from Mexico to the Arctic Ocean, as well as a large portion of the northern hemisphere in the Old World. They belong to the family of the squirrels (*Sciuridæ*) ; in fact, they are squirrels modified in a particular way for a terrestrial instead of arboreal mode of life. We are all familiar with the common little chipmunk of the eastern states, *Tamias striatus*, and know that, on comparison with a true tree squirrel, it differs in having a shorter and less bushy tail, in possessing large cheek pouches, etc. Now *Tamias* is just one step away from *Sciurus* towards the genus *Spermophilus;* and this genus is the group to which the prairie gopher belongs. In fact *Tamias* and *Spermophilus* very nearly run together, so gradual is the transition among the several species. If we were to take a chipmunk and crop its ears down close, cut off about a third of its tail, give it a blunter muzzle, and make a little alteration in its fore-feet, so that it could dig better, we should have a pretty good spermophile, to all intents and purposes. A little further change in the same points would make a prairie dog, which is a kind of spermophile, though now placed in a different genus (*Cynomys*). An extreme of modification, still in the same direction, gives us the squat, heavy woodchucks, *Arctomys*, between which and the lithe graceful tree squirrels we see that the chain of beings is unbroken. We see now just the links which the spermophiles furnish. They are terrestrial, fossorial, gregarious squirrels — by which I mean that they live sociably in burrows under ground. The broad prairie is their home. Though one or two species are found in wooded places, yet they rarely, if ever, climb trees, and are only at home in perfectly open ground. This fact alone determines their geographical distribution. Only two species are found at all east of the Mississippi, and these too haunt the prairie. But they occur in profusion from the plains to the Pacific, from Mexico northward.

Now that we have some idea of the animals, the next thing is

to find a name for them. "Ground squirrel" would be unobjectionable and indeed appropriate, but that is already in use for the species of *Tamias*. "Marmot" is sometimes used, the present species being the tawny marmot of some writers, but this is the name of the woodchucks (*Arctomys*). "Spermophiles" they have been called; but this word is so thoroughly un-English that it will probably stay in the learned books where it arose. Naturalists, in fact, have no English name for these animals. But by the people who live among them they are universally called "gophers;" and as this name will certainly stick in the vernacular for all time, we may as well accept it. We will say "gopher," then.

I elect to write about the prairie gopher — as I shall call that particular species known in the books as *Spermophilus Richardsoni* — for several reasons. In the first place, I know more about it than I do about any other species of the genus at present. Secondly, nobody else seems to know much about it. Thirdly, it is one of the most abundant animals of our country, occurring by hundreds of thousands over as many square miles of territory, almost to the exclusion of other forms of mammalian life. Millions of acres of ground are honeycombed with its burrows. Throughout a vast stretch of country in the northwest, gopher-holes and buffalo-chips are the most noticeable points about the landscape. How far from being exhausted is the natural history of the United States, when of such an animal as this next to nothing to the point is found written down about it, beyond a description of its skin and skull and a sketch of those characteristics which it shares with other *Spermophili!* Until recently, indeed, a stuffed skin of the prairie gopher was something of a rarity. Let me make such statements good: the latest authority on North American mammals says no specimens of this species were collected by any of the Pacific railroad expeditions, and makes use of one in the Philadelphia Academy for description, collected in the Rocky Mountains by Townsend more than thirty years ago. Prof. Baird is further at pains to record the fact that in 1855 Dr. Hayden met with a small spermophile, probably of this species, in considerable numbers, north of Fort Union, but was unable to procure specimens; and goes back to Sir John Richardson (1829) for some further items of geographical distribution. Audubon's biography is almost entirely from Townsend, who evidently knew the animal well, and is very good, as far as it goes.

During a considerable portion of two years, my lines have been cast in the very home of these animals; at any rate, I fancy they cannot be more abundant anywhere else. I have crossed the continent by another route, much farther to the southward, but I never saw any animals—not even buffalo—in such profusion. I have ridden for days and weeks where they were continuously as numerous as prairie dogs are in their populous villages. Their numbers to the square mile are vastly greater than I ever ascertained those of *S. Beecheyi*, the pest of California, to be, under the most favorable conditions. In a word, their name is legion. If Dakota and Montana were the garden of the world (which they are not, however), either the gophers or the gardeners would have to quit.

Should certain portions of the Territories just mentioned ever come to be settled, the little gophers will contend with the husbandmen for the land more persistently and successfully than the Indians can hope to. Already, though the population of the gopher districts has consisted principally of Indians and certain British-American surveying parties, these insignificant quadrupeds have killed men and horses. Their holes are small, but many of them, like the burrows of the badgers, foxes and prairie wolves, will admit a horse's hoof. The risks run in buffalo hunting on horseback spring chiefly from this source; what little the huge beasts themselves can accomplish in self-defence is utterly insignificant in comparison with this ever present danger. In some regions it is impossible to gallop a hundred yards except at risk of life or limb.

My observations on the prairie gopher have been confined to a narrow belt of ground along the parallel of 49°. Exactly how far they range on either hand I am unable to say — probably farther north than south. Perhaps the upper Missouri may nearly limit their dispersion southward. Speaking generally, they extend from the Red River of the North to the Rocky Mountains. Baird speaks of their occurrence in Michigan; but I never saw any in Minnesota, nor indeed in the immediate valley of the Red River, even on the Dakota side. There the genus is represented by *Spermophilus Franklini* and *S. tridecemlineatus*. But they appear in abundance just as soon as, in passing westward, we cross the low range of the Pembina Mountains, and strike perfect prairie, characterized by the presence of such birds as Sprague's lark and

Baird's and the chestnut-collared bunting. From this point they stretch clear away to the Rocky Mountains, subsiding only among the foot-hills of the main range, where the pocket gophers (species of *Thomomys*) begin to claim the soil; but a day's march, indeed, from the rocky haunts of the little chief hare (*Lagomys princeps*). The region of the Milk River and its northern tributaries, most of which, as well as the river itself, cross 49°, is their centre of abundance. Approaching this parallel from another direction, namely up the Missouri and across country northwesterly from Fort Buford,[1] I first met with them near the mouth of Milk River, and they almost immediately became abundant. They doubtless extend down the Missouri to the mouth of the Yellowstone beyond. Audubon gives the latitudinal distribution from 38° to 55°. The recently described *S. elegans* and *S. armatus* of Kennicott (Proc. Phila. Acad. 1863, 158), both being mere varieties of *Richardsoni*, carry the range of the species in the Rocky Mountain region down to the vicinity of Fort Bridger.

As already said, the gophers overrun all this prairie country. Travelling among them, how often have I tried to determine in my mind what particular kind of ground, or what special sites, they preferred, only to have any vague opinion I might form upset, perhaps in a few hours' more riding, by finding the animals as plentiful as ever in some other sort of a place. Passing over a sterile, cactus-ridden, alkali-laden waste, there would be so many that I would say "this suits them best;" in camp that very night, in some low grassy spot near water, there they would be, plentiful as ever. One thing is certain, however; their gregarious instinct is rarely in abeyance. A few thousand will occupy a tract as thickly as the prairie dogs do, and then none but stragglers may be seen for a whole day's journey. Their choice of camping grounds is however wholly fortuitous, for all that we can discover, and moreover the larger colonies usually inosculate.

What a country it is, to be sure, where the most persistent of the minor inequalities of surface are little heaps of dirt alongside of little holes! But about these holes, which I suppose I ought to describe, there is nothing remarkable whatever, except their numbers. They are all pretty much alike, yet no two are exactly the

[1] Fort Union, formerly a somewhat noted locality, now a mere heap of rubbish, stood about on the line between Montana and Dakota. Fort Buford, a flourishing post about two miles from the old site, now commands the mouth of the Yellowstone.

same. If we fancy an active, industrious, muscular little animal to begin to scratch with strong sharp claws, and to keep at work throwing out the dirt behind him till he has buried himself in a crooked passage that will just comfortably let him pass into the ground several feet below the surface, we have a good idea of the burrow. There is not the slight rule observed as to direction and distance, any more than there is as to location. An average sized burrow will just not admit a man's arm, except at the mouth, where it is usually funnel-shaped. It may go straight down, but generally slants very obliquely, and most frequently there is an elbow a foot or so from the surface. I do not think that the holes are anything like as deep as those of prairie dogs. I never dug one out, indeed, but I judge by the peck or bushel of earth usually thrown out, as well as by the fact that it is very easy to drown out the animals with two or three bucketfuls of water. Moreover, I am satisfied that the burrows do not, as a rule, intercommunicate — perhaps they never do, except by accident, when many animals are living side by side. Many holes are found with no earth at the entrance — a clean, circular opening in the grass. These are obviously points where the creatures have burrowed up to the surface again from below. If the animals have any preference, it is a choice of the lighter and more easily worked soils, rather than a question of location. They seem to haunt especially the slight knolls of the prairie a few feet above the general level. There the soil is looser, and the inhabitants have some little additional advantage in their view of the surrounding country. But there are plenty of burrows in the heaviest soil of the creek-bottoms. They dislike stony places for obvious reasons, yet they will often burrow beneath a single large rock. I have also found nearly horizontal holes of theirs dug from the face of an almost perpendicular bank. In short, there is endless diversity in the details of their habitations.

Of the underground life of the gophers I suppose no one knows much—certainly I do not. I am inclined to think the animals are essentially polygamous, which is a point to be considered in the question of the occupancy of the burrows. If they regularly paired, I think sufficient indication of the fact would not have escaped me. But I saw no signs of this occupation of a burrow by a pair. One gopher to a hole is the universal rule; that is, one gopher to an occupied hole. For the animals are very in-

dustrious, and in every thickly peopled region, the number of deserted burrows is out of all proportion to those in use. That not only the breeding female, but every other individual has his own domicile, cannot, I think, be doubted; and they appear to guard the gates jealously. For whenever, in the hurry of a sudden alarm, two or more gophers rush into the same hole, there is sure to be trouble. We hear, if we are near enough, a squeaking and commotion below, and the intruders are pretty sure to betake themselves off as soon as they dare. Doubtless different holes are put to different uses. The female must have her bed in which to be confined and rear her young. The male his permanent retreat. Some of the holes are storehouses. Then, I am persuaded, a great many of the shallower burrows are dug for temporary refuge and soon abandoned; for the gopher is an exceedingly timid animal, and must have a convenient place to hide. The storehouses I have discovered by accident and examined at my leisure. In places where small streams work through light soil, they continually form "cut-banks" along their convexities. By this undermining and fall of earth, burrows are frequently exposed. The storehouses I have seen were merely an enlarged excavation at the end of the passage, containing a hatful of the husks of grass seeds and the like.

There is one very curious point in the socialism of these animals. Every now and then, in odd out-of-the-way places, where there may not be another gopher for miles perhaps, we come upon a solitary individual guarding a well-used burrow, all alone in his glory. The several such animals I have shot all proved to be males; and what is singular, these old fellows are always larger than the average (some would weigh twice as much), peculiarly sleek and light-colored, and enormously fat. The earlier ones I got I suspected to be a different species, so peculiar were they in many respects. I suppose they are surly old bachelors who have foresworn society for a life of indolent ease, though if I had found them oftener among their kind I should have taken them for the Turks of the harem. It seems to be a case somewhat parallel with that of the lonely old buffalo bulls so often met with away from the herd.

The female brings forth in June. This I infer, at least, from the circumstance that July brings us plenty of young ones two-thirds grown. The young probably keep closely in the burrow until they

are of about this size — I do not remember to have seen any smaller ones running about. Without having seen a litter in the nest, I should judge the number of young produced at a birth to be about eight; at any rate, the female has constantly ten[1] teats; and July specimens, in worn harsh pelage, with all or nearly all of the teats in use, are frequently secured.

Of the life of the animal during the winter I know positively nothing. But two things are assured. They do not migrate, and they are not seen abroad. They must hibernate, and pass most of the long inclement season in a state of torpor. Such supplies of food as I have spoken of would not last an active animal so long.

However this may be, the gathering and hoarding of seeds seems to be their principal occupation during the summer. Amidst thousands that we pass only to see them skurry into their holes in trepidation, there are necessarily some observed which do not notice us, or at any rate do not take alarm. I have often watched them, where the grass was taller than usual, gathering their store. They rise straight up on their haunches, seize the grass-top, and bite it off. Then settling down with a peculiar jerk, they sit with arched back, and stow away the provender in their pouches with the aid of their fore paws. Their cheek pouches are not very large — both together would hardly hold a heaping teaspoonful. When duly freighted they make for their holes. Their mode of feeding, as they do, upon grass-blades or any other herbage, as well as upon seeds, is essentially the same. In their foraging excursions, they seem to have regular lines of travel. From almost every long-used hole may be seen one or more little paths, an inch or two wide, sometimes so well worn that they may be traced fifteen or twenty feet. These paths often run from one hole to another. No matter how smooth the ground, these paths are never quite straight; they repeat in miniature the devious footpath across the meadow, the mysterious something that prevents an animal from walking perfectly straight being in force here.

Though properly a vegetarian, like other rodents, the gopher is fond of meat, and I think that no small share of his summer's food is derived from the carcasses of buffalo. Wolves do not appear to be numerous, in summer at least, in this region, and the

[1] One pair axillary, one pair pectoral, two pairs abdominal and one pair inguinal.

polishing of buffalo skeletons is largely accomplished by the kit foxes, badgers, skunks and gophers. Hard by a slain buffalo a badger's hole is pretty sure to be soon established, together with a number of temporary gopher burrows. In proof positive of this carnivorous propensity, I have more than once seen the inside of a drying carcass completely covered with the peculiar and readily-recognized excrement of the gophers, while the bones and flesh were gnawed in a way that plainly told who had been there. The excrement is conico-cylindric, and thus very different from that of rabbits, the only other common rodents of the region.[3]

The voice of the gopher is peculiar — quite unlike the harsher and more guttural "barking" of the prairie dog. It is a sharp, wiry squeak of less volume, and is pitched in a higher key, than might be expected in the case of an animal of its size. It is a single note, repeated a few times. Comical as a gopher is in some of his attitudes and motions, he never looks so funny as when squeaking. He generally gets down on all fours to it, drops his jaw with a jerk, and squeezes out the noise by drawing in his belly — it reminds one of a toy dog. If caught or wounded, they have an energetic chattering outcry, much like that of other species.

There is not the slightest difficulty in securing any desired number of specimens — as is *not* the case with the prairie dog. Though equally timid, the gopher is neither so suspicious nor so warily cautious; nor is it so tenacious of life. As is well known, the chances are largely against securing a prairie dog shot at the mouth of his burrow. No matter how badly wounded, he generally manages in his death struggles to work down out of reach, and he not seldom, when shot dead, falls out of sight. But I would readily undertake to secure half the gophers fired at when fairly in sight, no matter if they were directly over the hole. Moreover a prairie dog, scared into his hole, will scarcely show his nose for a long time, while a gopher, more inquisitive or less prudent, generally pops up again in a few moments, to have another look, and vent his displeasure in a series of energetic squeaks. Advantage may be taken of this trait to secure him alive, by simply setting a noose around the hole, and retiring to a little distance, jerking the string smartly the moment the little animal's

[3] On slightly everting the anus (both sexes), there are seen three prominent conica papillæ around the margin, just inside — one anterior and one on each side.

nose appears. He is generally caught by the neck or around the chest. The soldiers used to have great fun this way sometimes, and I know of one man catching seventeen in about an hour. Fishing for gophers may not be very thrilling sport, but I should think, though I never tried it myself, that it would be quite as exciting as some other styles of angling.

I wish I could do justice to the rest of my subject — I mean to the variety of tricks and funny ways there are about a gopher, and without which no gopher is complete. But a gopher must be seen, and seen often, to be appreciated. For instance, a gopher caught away from home is a very different animal from one at the mouth of his hole. A most unreasonably timid animal, considering how rarely he is molested, he never goes out without feeling that he has taken his life in his hands. A thoroughly scared gopher is the liveliest object in nature; a mule kicking over the traces is perfect repose in comparison. He doubles up and opens out like nothing else I know of, with his absurd little whisk of a tail hoisted, and the way he gets over the ground without once looking back is amazing. Safe home, be he never so badly frightened, he will stop to see what was the matter. He pops bolt upright, stands stock still with his fore-paws drooped affectedly in front of him, looks demurely around, and squeaks out "Pooh! who 's afraid?" as plainly as possible. But let one come a step nearer, and down he goes on all fours, right over the hole, where he sits and scolds with back arched up, ready for a dive. When he does finally duck out of sight, there is no mistaking his meaning; the suggestive flirt of his tail, the last thing seen, speaks volumes to a thoughtful observer.

But one must not too hastily conclude that a gopher on the prairie is always in a flurry, or that one at home is always saucy. On the contrary, like other frolicsome, heedless little creatures they are sometimes wofully imprudent, and will gambol about almost at one's feet, or enter a tent to forage for food. They are the life of the prairie, and they have afforded, to me at least, no little real pleasure. I like to watch them undisturbed, they are such pretty, sleek, comfortable creatures, so full of life, so busy, so bright. They always look as if they would like to know you better if they dared, and when they give you up as an impossibility, they go off in zigzag with mincing steps, stopping every few paces, half inclined to come back after all. A gopher never quite

knows his own mind. But the prettiest of all the exhibitions a gopher can make of himself, is when he frames his profile in the rim of his burrow. Not seldom, after running some little fellow to earth, have I stood still just by the hole, and confidently waited for his reappearance. Presently I hear a little scratching, perhaps a squeak, and then I see his head, turned roguishly to one side, to throw one bright black eye full upon me, as if to ask what manner of creature I may be to stand thus boldly at his door. He looks as if he would like to invite me in, and then laugh at me for being too big and too clumsy to enter.

A STATE SURVEY FOR MASSACHUSETTS.

BY PROF. N. S. SHALER.[1]

WHILE Hayden with his score of coadjutors is skirmishing over the unexplored recesses of the West, reconnoitring an empire in a season, the surveyors of Great Britain are patiently unriddling their islands at a rate that will require a century for its completion.

It must not be supposed because these two kinds of workers differ so widely in their methods that either is mistaken. Each is doing legitimate work in its sphere, and each has its important scientific and economic results. Perhaps the best specimen of this system of reconnoissance work which has ever existed is now in operation in this country, under the charge of Dr. Hayden; other expeditionary surveys under the charge of Mr. Clarence King and Major Powell, have shared with Hayden the task of unravelling the complicated geology and topography of the vast area lying between the eastern and western borders of the Cordilleras of North America. The present system pursued by Hayden is admirably suited to secure the most rapid delineation of a country for correct sketch maps. A system of triangles is carried across country from mountain-top to mountain-top, so that a large number of positions are accurately determined. From good points of view the topographer delineates the intermediate country by the

[1] The following extracts are taken from an article in the "Atlantic Monthly" for March. We regret that we have not space to reprint the article entire, as it forms an admirable presentation of the subject of surveys in general.— EDS.

use of the theodolite; contour lines, or lines supposed to represent equal heights above a water level, are sketched in with some detail, so that the eye catches the true reliefs of the country. Along with these topographical parties go geologists and collectors of specimens, to illustrate the geology and biology of the country. This survey is carried on at such speed that in a season of four or five months a single party will work in several thousand square miles of territory and obtain a remarkably good idea of all its important features. Several of such parties together make up the expedition, and the reports set forth, with a fair accuracy, the topography, geology, zoölogy, botany, agricultural resources, and such information as can be gained concerning the climatology of the district surveyed. It is difficult to imagine a plan better calculated than this to accomplish the end in view, namely, to discover the general characters of an unexplored land, and to guide the coming immigrant in its development by the steady light of science.

The state of Massachusetts is a remarkably favorable state for illustrating the methods in which a survey should be conducted; not such a survey as a new Western State makes in order to get some idea of where its coal and iron lie, and the amount of its wealth, but a work intended to be the most exact and final work which it is possible to do on the earth's surface. When a government approaches so considerable an enterprise as this, and determines that it is to be done so as never to require, in our day at least, a reconstruction, all geologists will agree that the first thing is to secure the best map. Massachusetts has the good fortune to have her shore-belt map completely made by the Coast Survey; Cape Ann and Cape Cod and the bordering islands, making, together, about a tenth of the total area of the state, have all been done on the scale of one ten thousandth, or about six inches of map to the mile of distance. If it were practicable, this map should be continued on the same scale over the whole state, making, when finished, a record map about ninety feet long and fifty-four wide; on this scale every important detail could be truthfully laid down. This is the proper thing to do, and nothing but the cost of the work can be urged against it; on this plan the surveying and improvement of private grounds could always be accomplished, tax-levies made, in short, our civilization could be organized upon it. If something else less perfect must be done, it will be with the greatest regret that we turn to it from our ideal.

On this perfect system the topography alone would be likely to cost over half a million of dollars and pretty certain not to exceed three-quarters of a million, or about as much as one thousand feet of the Hoosac Tunnel. Who will say that Massachusetts cannot afford this sum for a perfect record of the theatre of her industries? If, however, it be thought that it is better to temporize with the matter, it will certainly be possible to get the most important results with a smaller original map — one twenty-five thousandth, or about two and a third inches to the mile, will answer for most of the great economic purposes of a survey; it will not, however, serve as a tax map or for the management of individual estates, and in time it would have to be done over on the larger scale. The dimensions of the original maps, it should be noted, is quite another matter from the size they have in their published form; from the original records reductions can be made to any scale.

When this topography is far enough advanced to give a basis for other work, the geology and biology should be taken in hand. Here we come upon a class of researches which require some special consideration. What should be the objects of this scientific work, and how are these objects to be attained? To answer these questions at length is to discuss all the methods and aims of science. There are some limitations, however, which are worthy of note. Any state, however small, furnishes problems organic and inorganic, which will require centuries for their complete discussion. As we do not propose that a survey shall take up at once all the problems of science, it becomes a nice matter to limit the work. In the geology this is comparatively easy; no amount of detail consistent with the condition of the science will be superfluous here; every stratigraphical question, every question in chemical geology, should be followed to its utmost point. Each region supplies the investigator with special problems which he knows whenever the general structure of a country is known; it is the special object of a reconnoissance to show what and where these problems are. Some of them are economical, have money in them; the others are economical too, in that higher sense which finds all truth profitable. Of those which connect themselves immediately with industry we may mention the following questions: (1) the distribution of water, its storage and quality; (2) the building-stones of the state; (3) the existence of deposits of coal in workable quantities; (4) the distribution of metals, the iron of the

western region, and the silver-bearing beds of the east; (5) the reclamation of marshes; (6) the retimbering of the exposed parts of the coast. Among the scientific problems, the state affords some matters of surpassing interest. Probably no other known fossils have so much value for the science of to-day as those wonderful footprints of the Connecticut Valley. They deserve years of study and the thorough investigation which can only be given by a careful re-survey of the whole region.

Among the many problems concerning the existing life of the state, it is difficult to give in a word the most important. A large part of the necessary work for the complete description of our animals and plants is already done, and needs but to be assembled and ordered. The state is already rich in investigators, and as soon as a survey begins, these will be increased; from their labors we may hope for a thorough study of the biology of Massachusetts. The state has already taken advanced ground concerning instruction in natural history. It will greatly aid the work of diffusing a knowledge of nature throughout the people, to have carefully edited catalogues of all the animals and plants existing within the state, with enough concerning their characters, habits, etc., to make the information of practical value to beginners. This work need be of very little expense to the survey; the state already has nearly a million of dollars invested in the Museum of Comparative Zoölogy, and in the work of cataloguing the animals this noble institution can make a substantial return through the students it has trained and the collections it has accumulated. Managed with discretion, this survey could not fail to bring about a great interest in science in our public schools of all grades. With good maps and good catalogues of the natural productions of a country, the teaching of natural science becomes possible to a degree that cannot be hoped for under other circumstances. This is to Massachusetts a matter of great importance; her real greatness has lain and always must lie in her power to produce men preëminently fitted for the work of their day. Other states can, almost without effort, beat her in the race for material greatness, strive as she may against it; but her intellectual lead, now so clearly established, may be maintained to the end if she but care to take the steps necessary to keep her energies bent towards this object. She must now foster science as she has established and fostered theology and general learning.

THE MODE OF GROWTH OF THE RADIATES.

BY A. S. PACKARD, JR.

I. THE HYDROIDA.

THE animal next higher in structure than the sponge is the curious Protohydra discovered by Greef among diatoms and sea-weeds in the oyster park at Ostend. It is regarded by Greef as the marine ancestral form of the Cœlenterates (Hydroids, Jelly fishes and Actiniæ). It is the simplest possible radiate form yet discovered. As the form of the fresh-water Hydra is familiar, Protohydra may be best described as similar to that, except that it is entirely wanting in tentacles. Like Hydra it is made up of two layers (an ectoderm and endoderm), with a mouth and stomach (gastro-vascular cavity). Nothing is known of its history, though Greef is positive that it is not a young Actinia.

The next highest form is the fresh-water Hydra, which is commonly found on the under side of the leaves of aquatic plants. This well known animal is the simplest form of the division of radiates known as Hydroids. The somewhat club-shaped body consists of two layers, the inner (endoderm) lining the general cavity of the body, which serves both as mouth and stomach and for the circulation of the nutritive fluid, and is called the gastro-vascular cavity. The mouth is surrounded with eight tentacles, which are prolongations of the body-wall and are hollow, communicating with the body cavity.

Such is the general structure of the Hydra. In the ectoderm are situated the lasso-cells or nettling organs, being minute barbed filaments coiled up in a cell-wall. From Kleinenberg's recent researches on the Hydra it appears that there are scattered irregularly through the endodermal lining of the body-cavity isolated ciliated cells. They do not form a continuous lining membrane, and thus bear an interesting analogy to the ciliated cells of the sponge. While the endoderm forms a simple cell-layer, the outer layer (ectoderm) is more complex, as just within an external simple layer of large cells is a multitude of smaller cells, some of them being thread or lasso cells, while still within are fine muscular fibrillæ which form a continuous layer. The large cells first

named end in fibre-like processes, which alone possess contractility and are thought by Kleinenberg to be motor-nerve endings. These large cells, from combining the functions of muscle and nerve, are termed "nervo-muscle cells." The little cavities between the large endodermal cells and the muscular layer which lies next to the endoderm is filled with small cells and lasso-cells, forming what Kleinenberg calls the interstitial tissue. From this tissue are developed the eggs and spermatozoa.

The organization of all the hydroids and even Lucernaria and the larger jelly-fishes (Discophora) is based on the plan of the Hydra. They all have a simple body-cavity, but no true alimentary canal surrounded by a perivisceral cavity. This is the distinguishing character of the Cœlenterates. In the jelly-fishes, the often complicated water vascular system of canals are simply passages leading out from the axial gastro-vascular cavity. If we place a jelly fish in the same position as the Hydra, *i.e.*, with the tentacles directed upwards, the general homology between the parts can be clearly traced. In the Hydroids, such as Sertularia, etc., the ectoderm is surrounded by a chitinous sheath, secreted from this layer. While in Hydra the young bud out from the side of the body, in the Hydroids the young are developed on a separate stalk from the barren or nutritive stalk or "zooid." The individual Hydroid is thus subdivided into a reproductive and a nutritive zooid, The reproductive zooids seldom or never take in food, but are nourished by the nutritive zooids, the two zooids being connected by a common creeping stem called the "cœnosarc."

The Anthozoa or sea anemones and coral polypes differ from the Hydroids and Medusæ in having the stomach open at the bottom into a second and larger cavity communicating with the radiating chambers. In the Ctenophora there is a decided approach in the complication of the body to the Echinoderms. The radiated structure so clearly shown in the lower forms is here in part subordinated to the bilateral arrangement of parts; they have a right side and a left side. They also differ in the mouth opening into a wide digestive cavity, enclosed between two vertical tubes, uniting at the end of the body, where the stomach forms a reservoir for the gastro-vascular tubes ramifying throughout the body. They move by a peculiar apparatus consisting of bands of comb-like flappers. Not detaining the reader with a definition of the subdivisions of the Cœlenterates we shall be content with

giving the following tabular view of the lowest subdivision of Radiates :—

CŒLENTERATA.

ACALEPHS OR HYDROZOA.
1. *Hydroida.* a. Hydriform (Hydra, Hydractinia, Tubularia, Sertularia)
b. Siphonophora (Velella, Agalma, Physalia).
2. *Calycozoa* (Lucernaria).
3. *Medusæ* or *Discophoræ* (Aurelia.)
ANTHOZOA (Actinia, Cerianthus, Astræa, Alcyonium, Gorgonia and Renilla).
CTENOPHORÆ (Beroë, Cydippe, Cestum).

Development of Hydra and the Hydroids. Ehrenberg first showed that the Hydra reproduced by eggs which become fertilized by spermatic particles. Kleinenberg describes the testis, which is lodged in the ectoderm and which develops tailed spermatozoa like those of the higher animals. They arise, as in other higher animals, from a self-division of the nuclei of the testis-cells. There is a true ovary formed in the same interstitial tissue of the ectoderm, consisting of a group of cells, which differ entirely in their mode of formation from the ovaries (gonophores) of the marine Hydroids, which are genuine buds.

It thus seems that Hydra is monœcious or hermaphrodite, *i. e.*, the sexes are not distinct. The egg of Hydra originates from the central cell of the ovary; thus confirming the opinion now generally held that all animals as a rule arise from a simple cell. After the egg-cell has escaped from the ovary through the ectoderm, it still holds on by a narrow point to the sides of the Hydra, where it is fecundated by the spermatic particles discharged into the surrounding water from the testis.

Fecundation is succeeded by a true segmentation of the egg. The young Hydra thus passes through a true "Morula" stage.[1] There is an outer layer of prismatic cells, forming the surface of the germs, and surrounding the inner mass of polygonal cells. At first none of these cells are nucleated, but afterwards nuclei appear, and it is an important fact that these nuclei do not arise from any preëxistent egg-nucleus.

The next step is the formation of a true chitinous shell, enveloping the germ or embryo. After this Kleinenberg asserts that the cells of the germ become fused together, and that the germ is like an unsegmented egg, being a single continuous mass of protoplasm. Allman remarks that "as this phenomenon does not occur

[1] Hereafter we shall often use Hæckel's convenient term "Morula," instead of "stage of segmentation of the egg," for the sake of brevity.

in other Hydroids it can have no general significance for the development of the order."

The remaining history of Hydra is soon told. In this protoplasmic germ-mass there is formed a small excentric cavity; this is the beginning of the body-cavity, which finally forms a closed sac. Allman remarks on this discovery of Kleinenberg's that "it is clear that the formation of a body cavity by invagination of the walls [*i. e.*, ectoderm] with the significance which Kowalevsky has assigned to it in other animals, does not exist in Hydra, and just as little will it be found in any other hydroid." It will be seen farther on that in certain medusæ, Kowalevsky has discovered that the digestive cavity is formed by the invagination of the ectoderm, and we have seen (p. 107) that Metznikoff declares that the ciliated cells lining the gastro-vascular cavity in the embryo of the sponge are the originally external ciliated cells of the planula withdrawn into and lining the body cavity.

After several weeks the germ bursts the hard shell and escapes into the surrounding water, but is still surrounded by a thin inner shell. After this a clear superficial zone appears, and a darker one beneath, which is the first indication of the splitting of the germ into the two definitive germ-lamellæ, common to all animals except the one-celled Protozoa.

The embryo soon stretches itself out, a star-shaped cleft appears, which forms the mouth. The tentacles next appear. The animal now bursts open the thin inner shell, and the young Hydra appears much like its parent form.

There is, then, no metamorphosis in the Hydra; no ciliated planula. The adult form is thus reached by a continuous growth.

It will be seen, to anticipate somewhat, that the Hydra, exactly as in the vertebrates, including man, arises from an egg developed from a true ovary, which is fertilized by a true tailed spermatic particle; that the egg passes through a morula stage; that the germ consists of two germinal layers, while from the outer layer, as probably in the vertebrates, an intermediate or nervo-muscular layer is formed, which Allman thinks is the homologue of the middle germ-lamella of the vertebrates, supposed to have originally split off from the ectoderm. Allman even regards the chitinous shell of the germ of Hydra as the equivalent of the epidermis of vertebrates, being a provisional embryonic organ in Hydra, but permanent in vertebrates.

In all the marine Hydroids, which are more complex in their individualism than Hydra, the sexes being separate, the eggs and spermatic particles are thought by Allman to be developed from the endoderm. But E. Van Beneden has on the other hand shown that the eggs in Hydractinia are exclusively developed from the endoderm, while the spermatic cells arise from the ectoderm.

The simplest form next to Hydra is Hydractinia, in which the individual is differentiated into three sets of zooids; *i.e.*, *a*, hydra-like, sterile or nutritive zooids; *b* and *c*, the reproductive zooids, one male and the other female, both being much alike externally, having below the short rudimentary tentacles several spherical sacs, which produce either male or female medusæ. These medusa buds or closed generative sacs are fundamentally like the free medusæ in structure. The marine Hydroids, then, are universally diœcious, and usually each colony is either male or female.

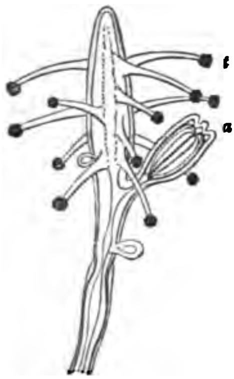
A rather more complicated form is the common *Coryne mirabilis*. Fig. 51 shows the hydrarium with its long tentacles (*t*) and *a* the medusa buds, Fig. 52 its free medusa. Tubularia is a higher form, and allied to the latter is still another form, *Corymorpha pendula* (Fig. 53. After Agassiz).

Figs. 54–58 (after A. Agassiz) represent quite fully the life history of another Tubularian, *Bougainvillia superciliaris*. Fig. 54 represents the hydrarium, with the sterile zooids provided with long tentacles, and the medusa buds of different ages. Fig. 55 shows a bud still more enlarged, with the proboscis (manubrium) just formed, and knob-like, rudimentary tentacles. In an older stage (Fig. 56) the proboscis is enlarged and the tentacles lengthened, while the depression at the upper end indicates the future opening. In Fig. 57 the appendages of the proboscis are plainly indicated, the tentacles are turned outwards. Shortly after this the jelly-fish breaks loose from its attachment and swims around as at Fig. 58.

How do the zooids first arise? This leads us to speak of the simplest mode of reproduction in the Hydroids, which is by budding. The object of sexual reproduction, *i. e.*, by eggs and spermatozoa, throughout the animal and plant world, is by bringing the germ or portion of protoplasm of one individual, which is an epitome potentially of its physical and psychical nature, to mingle with that of another of the same species, so that the offspring may combine the qualities of both parents, and not deteriorate. The

species can be reproduced simply by budding, but the result would, if maintained for a number of generations, in the end prove disastrous to its integrity. Nature abhors self-fertilization. So that while, as in these Hydroids, the zooid form may be produced by budding, yet the time comes when the individuals of one colony must mingle their reproductive elements with those of a remote colony, through the medium of the water. By this mode of repro-

Fig. 51.

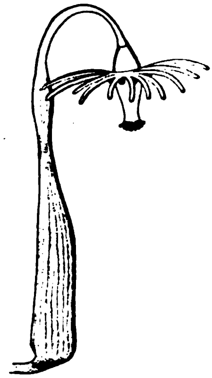


Polypite of Coryne mirabilis, with a bud below a, and medusa bud, (gonophore) above. a, much enlarged. After Agassiz.

Fig. 52.

Free medusa of Coryne thrown off from the gonophore. Natural size. After Agassiz.

Fig. 53.



Corymorpha.

duction new colonies are also set up. On the other hand budding or gemmation has for its object the extension of the colony of nutritive and reproductive zooids. This alternation of budding with sexual generation or "alternation of generations," or "parthenogenesis," is first met with in the Hydroids, and we shall find it often recurring in the higher animals when needed to meet some special exigency of the species.

Fig. 54.

Hydrarium of Bougainvillia, magnified.

Fig. 56.

Medusa bud of 54, farther advanced.

Fig. 55.

Medusa bud of 54.

Fig. 57.

Medusa bud with the tentacles turned out. Magnified.

Fig. 58.

Medusa of Bougainvillia. Magnified. After A. Agassiz.

Budding begins as a slight protrusion of the basal portion (cœnosarc) of the colony, which then becomes spherical and finally club-shaped, as in Fig. 51, until it assumes the form of a zooid. It remains permanently attached in all the Hydroids except in Hydra, where it breaks off and bears a free individual. In some species of Tubularia the heads of the zooids successively drop off, and are renewed.

Multiplication by fission has only been observed in one case, in the medusa of Stomobrachium, observed by Kölliker at Messina. In this the pendent stomach divided in two, becoming doubled, which was followed by a vertical division of the umbrella, separating the animal into two independent halves. These again subdivided, and Kölliker thinks this process went on still farther.

The second mode of generation, *i. e.*, by eggs and spermatic particles, have been observed in many marine Hydroids. As in the Hydra, the eggs, after being fertilized, pass through a morula stage, and finally the germ becomes surrounded by a blastoderm, as in Hydra, formed of long prismatic cells directly comparable with the zone of blastodermic cells of insects, and many other animals, including the mammals. The germ elongates and finally escapes from the ovisac (gonophore) of the parent as a ciliated "planula," a term first applied to it by Dalyell.

Now how do these planulas become converted into hydras, and through them into medusæ? A glance at the accompanying figures will give the main points in the life history of a not uncommon Hydroid found on our shores, a Melicertum allied to Campanularia (Fig. 62). We are indebted to Mr. A. Agassiz (Seaside Studies in Natural History) for the following facts and illustrations regarding its history. After keeping a number of the Melicertum in a large glass jar for a couple of days at the time of spawning, he found that the ovaries, at first filled with eggs, became emptied, and that the planulæ, at first spherical and afterwards pear-shaped (Fig. 59) swam near the bottom of the jar, and soon attached themselves by the larger end to the bottom of the jar (Fig. 60). "Thus their Hydroid life begins; they elongate gradually, the horny sheath is formed around them, tentacles arise on the upper end, short and stunted at first, but tapering rapidly out into fine, flexible feelers; the stem branches, and we have a little Hydroid community (Fig. 61), upon which, in the course of the following spring, the reproductive calycles containing the medusæ buds will be developed."

Fig. 59.

Planula of Melicertum.

Fig. 60.

Cluster of Planulæ just attached to the ground.

Fig. 61.

Polypites of Melicertum developed from the planulæ; greatly magnified.

Fig. 62.

Melicertum campanula, seen in profile. Natural size. After Agassiz.

Coming now to the Portuguese man-of-war (Physalia) which have so much occupied the attention of the best naturalists, it would seem at first well nigh impossible to trace their relationship with the ordinary Hydroids. A Physalia may, however, be compared to a fixed colony of Hydractinia or Coryne, for example. Each Physalia is either male or female, and consists of four kinds of zooids; viz., nutritive and reproductive, with medusa buds, which, by their contractions and dilatations propel the colony onward; and the "feeders," a set of digestive tubes which nourish the entire colony.

The Siphonophores (as observed by Gegenbaur, Kowalevsky, Hæckel and Metschnikoff, in Agalma and several other genera) arise from eggs which pass through a morula stage, into a ciliated planula, whose body consists of an ectoderm and endoderm. The gastro-vascular cavity in the Siphonophores, as in the lower Hydroids so far as observed, is formed by a fold of the endoderm, while, as we shall see farther on, in the Discophorous jelly fishes it is formed by an infolding of the ectoderm.

The further development of Nanomia, a Siphonophore native to our northern shores, from the larval state, has been described and figured by Mr. A. Agassiz. To use nearly his own words, the Nanomia consists, when first formed, of an oblong oil bubble, with but one organ, a simple digestive cavity. Soon between the oil bubble and the cavity arise a number of medusa buds, though without any "proboscis" (manubrium), as these medusa buds, called "swimming bells," are destined to "serve the purpose of locomotion only, having no share in the function of feeding the community." After these swimming buds, three kinds of Hydra-like zooids arise. In one set the Hydra is open-mouthed, and is in fact a digestive tube, its gastro-vascular cavity connects with that of the stem, and thus the food taken in is circulated throughout the community. These are the so-called "feeders." The second set of Hydras differ only from the "feeders" in having shorter tentacles twisted like a corkscrew. In the third and last set of Hydras the mouth is closed, and they differ from the others in having a single tentacle instead of a cluster. Their function has not yet been clearly explained. Gradually new individuals are added, until a long chain of Hydroids is formed, which move gracefully through the water, with the oil globule uppermost, which serves as a float and is identical with the large-crested "float" of the Physalia.

Finally, the higher Hydroids, such as Æginopsis, Ægineta Cunina and Lyriope have been found by Muller, Agassiz, McCrady, Leuckart, Gegenbaur, Fritz Muller and others, to develop directly from eggs and pass through a metamorphosis as medusæ. During the past year (1874) Metschnikoff has published, with many figures, an account of the development of Geryonia, Polyxenia (Ægineta) and Æginopsis.

In these animals the egg passes through a morula stage; an outer layer of cells (blastoderm) splits off from the morula, forming the ectoderm and entoderm. The embryo, then, as in Polyxenia, passes through a ciliated planula stage. The embryo may remain spherical, as in Geryonia, or as in Polyxenia and Æginopsis, the body of the planula becomes greatly elongated and bomerang-shaped, and from each end are developed the first two tentacles, then others, and after a slight metamorphosis the adult form is attained.

The life history of the Hydroids comprises, then, the following phases in development:—

1, *a*. Origin of young Hydra by budding.
b. Origin of embryo from egg fertilized by spermatozoa.
2. Morula stage.
3. Planula (Gastrula) stage.
4. Hydra-like form, attached.
5. Medusa, free and discharging eggs.

LITERATURE.

Gegenbaur. Versuch eines Systemes der Medusen (Siebold and Kölliker's Zeitschrift, 1857).

McCrady. Gymnophthalmata of Charleston harbor (Proc. Elliott Soc. N. H., i, 1859).

L. Agassiz. Contributions to the Natural History of the United States, vol. 3 and 4. 1860 and 1862.

Allman. Report on the Present State of our Knowledge of the Reproductive System in the Hydroida. (Rep. Brit. Assoc. Adv. Sc., 1863).

Clark. Mind in Nature. 1865.

A. Agassiz. Catalogue of the Acalephæ of North America. Mus. Comp. Zool., 1865.

E. C. and A. Agassiz. Seaside Studies in Natural History. Radiates. Boston, 1871.

Kleinenberg. Hydra, eim Anatomisch-entwicklungsgeschichliche Untersuchung. Leipzig, 1872. (Abstract, with notes by Allman in Quatr. Journ. Micr. Science, 1874.)

Metschnikoff. Studien ueber die Entwickelung der Medusen und Siphonophoren (Siebold und Kölliker Zeitschrift 1874).

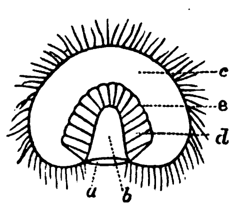
II. THE MEDUSÆ (Discophoræ).

Passing by the Lucernaria, beautiful and interesting, but of whose early development we know nothing, we come to the common

larger jelly-fishes of our shores, which differ from the bell-shaped hydroid medusæ in their usually larger size and solid disk, as well as in the larger number and greater complication of the water tubes, which ramify and interbranch along the under side of the disk; and in carrying their eggs in pouches. In our common *Aurelia flavidula* there are four of these large pouches occupying the centre of the disk.

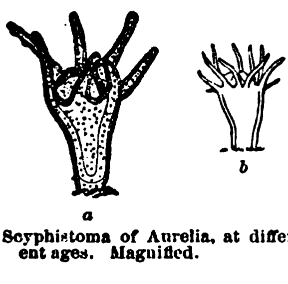
The life history of the Aurelia, which we will select as an example of the mode of development of this group, since it is best known, is far less complicated than that of the Hydroids. The ciliated planulæ may be found in the egg pouches of the female Aurelia during the last of summer. Soon after the ectoderm and entoderm are formed, a mouth is developed, and a gastro-vascular cavity is formed by the invagination of the ectoderm, as stated by Metschnikoff, and they then pass into a gastrula (planula) stage (Fig. 63, Gastrula of a form allied to Aurelia; *a*, mouth; *b*, gastro-vascular cavity; *c*, ectoderm; *d*, entoderm; after Metschnikoff), with a mouth and long digestive cavity. After swimming about for a while they fix themselves to some object at the bottom of the sea and soon a

Fig. 63.



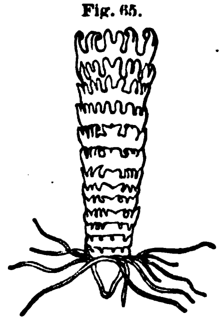
Gastrula of an Aurelia-like Medusa.

Fig. 64.



Scyphistoma of Aurelia, at different ages. Magnified.

Fig. 65.



Strobila of Aurelia.

pair of tentacles begin to develop, and then two more, until not more than sixteen are developed. When of this hydra-like form (Fig. 64 *a*, young; *b*, older, after A. Agassiz) it is called a "Scyphistoma," having originally, as well as the Strobila and Ephyra,

been mistaken forand described as an adult animal under that name.

After assuming this scyphistoma condition, transverse constrictions appear at regular intervals, dividing the column, as it were, into a pile of saucers; the edges rise, tentacles bud out, and the animal assumes the form seen in Fig. 65 (after Agassiz). The uppermost disk becomes detached, the rest separate one after the other and float away in the form of an "Ephyra" (Fig. 66, after A. Agassiz) and after some weeks assume the aurelia or adult condition (Fig. 67). The gigantic *Cyanea arctica*, which attains a diameter of from three to five feet across the disk, as Agassiz remarks, is produced from "a hydroid measuring not more than half an inch when full-grown."

Fig. 66.

Ephyra of Aurelia.

On the other hand there are several exceptions known to this mode of development, a few growing directly from the egg, without passing through a hydra, or scyphistoma stage. Such is the large Pelagia, as observed by Krohn. Mr. A. Agassiz has observed the same fact in *Campanella pachyderma*, a minute jelly fish.

Fig. 67.

Aurelia flavidula. After Agassiz.

The Discophores, then, develop in two ways :—

A. Directly from the egg (Pelagia and Campanella).

B. From hydra-like young arising from eggs (Aurelia and Cyanea) and presenting the following phases of growth:—

1. Egg.
2. Morula (?)
3. Planula (Gastrula).
4. Scyphistoma.
5. Strobila.
6. Ephyra.
7. Aurelia (adult).

LITERATURE.

Nearly the same as for the Hydroids.

REVIEWS AND BOOK NOTICES.

HAYDEN'S GEOLOGY OF COLORADO.[1]—Within this bulky volume of over seven hundred pages is contained a mass of geological, topographical and biological facts concerning Colorado, which it must be confessed reflect great credit on the management of the survey and the industry of the gentlemen employed upon it. Large appropriations have been made by the government for the survey, as accurate and timely information was wanted. We do not see but that ample and speedy returns have been made. The best possible topographical work was wanted, and the public have it from the best possible source. Information concerning the mines of Colorado is here given, while the bulk of the volume is taken up with the legitimate kind of work to be expected from such a survey. To this are to be added reports on the fossil animals and plants, and the living animals and plants of Colorado, thus making it a handbook for the general reader and traveller as well as scientist.

The geological and palæontological work (fossil plants as well as animals) and the living animals, are more fully illustrated than in former reports. The outline illustrations, showing the topography in combination with the geology, are admirable. We have

[1] Annual Report of the United States Geological and Geographical Survey of the Territories, embracing Colorado, being a report of progress of the exploration for the year 1873. By F. V. Hayden, U. S. Geologist, Washington, D.C. 1874. 8vo. pp. 718. With maps and illustrations.

obtained clearer ideas than ever before of the scenic features of the Rocky Mountains.

The elevated plateau and mountains of Colorado have a unique interest to the naturalist. Most interesting questions in the distribution of life, both horizontal and vertical; the relation of the physical aspects of Colorado as compared with the plateaux of Asia and the mountains arising from them, will find a partial solution in the data given in this report.

In the first eighty pages Dr. Hayden describes the chief objects of geological interest from Denver to the south and middle parks. Some interesting facts are given concerning the ancient glaciers of Colorado. He says that there is evidence that the Arkansas valley was formerly filled with an enormous glacier with branches of greater or less magnitude, leaving lake basins, moraines and immense granite bowlders scattered over the surfaces. The figure[2] on page 177 is a view of the rounded and polished rocks in the valley of a stream which rises among a group of peaks of which the Mountain of the Holy Cross (Fig. 68) is the most conspicuous. "The mountains on either side rise to the height of 2,000 to 3,000 feet above the valley, and the glacial markings are visible 1,200 to 1,500 feet. The morainal deposits on the northwest side reach a height of 1,200 feet above the stream, and form a sort of irregular terrace, which, when cut through by the little side-streams, show that it is made up of gravel and bowlders much worn. In some instances there are well-worn cavities in the sides of the mountains, showing how the running water, in connection with a mass of rock, formed the cavity much as a 'pot hole' is made in our streams at the present time. Many of the 'sheep backs' are still covered with a crust-like enamel, but usually this has peeled off."

Returning to the Mountain of the Holy Cross, we are told that the main mass of the peak, like the whole of the Sawatch range, is composed of granite gneiss. The summit of the Holy Cross is covered with fragments of banded gneiss. The amphitheatres on all sides have been gradually excavated, as heretofore described, and the more or less vertical sides show the intermediate steps very clearly. The characteristic feature of the Mountain of the Holy Cross is the vertical face, nearly 3,000 feet on the side, with

[2] We are indebted to the courtesy of Dr. Hayden for the use of electrotypes of the accompanying figures.

Fig. 68.

Mountain of the Holy Cross, Colorado.

Fig. 69.

Gothic Mountain, Elk Range, Colorado.

Fig. 70.

Italian Mountain, Colorado.

a cross of snow which may be seen at a distance of fifty to eighty miles from other mountain-peaks. This is formed by a vertical fissure about 1,500 feet high, with a sort of horizontal step, produced by the breaking down of the side of the mountain, on which the snow is lodged and remains more or less all the year. Late in the summer the cross is very much diminished in size by the melting of the snow which has accumulated in the fissures. A beautiful green lake lies at the base of the peak, almost up to

Fig. 71.

Rounded Rocks on Roches Montonnées Creek. Colorado.

timber line, which forms a reservoir for the waters from the melting snows of the high peaks."

The contrast of the volcanic peaks with the granite mountains is seen in the accompanying sketches of Gothic mountain (Fig. 69) and Italian mountains (Fig. 70).

The reports on the geology of special areas are by Messrs. Marvine, Peale and Endlich, and are fully illustrated with maps and sections. The report on fossil plants by Mr. Lesquereux contains valuable remarks on the age of the North American Lignitic formation, the climate of the North American Tertiary Period, ac-

companied by descriptions of a large number of new fossil plants. Prof. Cope's report on the fossil vertebrates of Colorado contains descriptions of several new species with eight lithographic plates illustrating them. The zoology of Colorado is treated of in papers by Lt. Carpenter, Baron Osten Sacken, Dr. Hagen, and Messrs. Ulke, Smith, Verrill, Binney, and Packard. The report on the geography and topography of Colorado, by Mr. James T. Gardiner, possesses a high degree of interest, and is an important contribution to American geography.

BOTANY.

THE LOTUS IN THE DETROIT RIVER. — Early in the summer of 1868, I attempted the introduction of the Lotus or Chincopin (*Nelumbium luteum* Willd.) into the Detroit River, by planting the seed in nine different places. In company with Mr. Richard Storrs Willis, I planted (May 2, 1868) some of the seed in three places in the Bayou, at his residence at Belle Isle. Mr. Willis subsequently informed me that one plant was the result of my sowing; but I do not know that it ever arrived at perfection. I have not known of my other locations resulting in even this partial success. But last summer, at a field meeting of the Detroit Scientific Association, at Grosse Isle, several of the flowers of this beautiful species were brought me for determination by Miss Douglass, who had discovered and gathered them the day before (August 11, 1874) in the Cannard River, Ontario (a tributary of the Detroit) opposite Grosse Isle. They may have been overlooked there a long time. The year previous a young lad had told of finding, in the Cannard, a water lily different from all others, which led to the above result.

A gentleman has also succeeded in growing the plants from seed in the Rouge River, which falls into the Detroit a few miles below the city. They blossomed for the first time last summer. Another friend, who sowed the seed a year or so ago, has had as yet no appearance of its growth. I am aware that it often takes years to germinate after planting. On August 12, 1872, a seed which I had planted in my aquarium, 4½ years before, rose to the surface of the water in the act of germinating. It afterwards sank to the bottom, and settling in the mud, but not rooting, sent out a long shoot, which (leaf and petiole), on August 17, in 24 hours, grew 4½ inches in length, the weather being very warm.

One could almost *see* the growth. Another seed planted at the same time and in the same place germinated in one year. — HENRY GILLMAN, *Detroit*, *Mich.*

ZOOLOGY.

THE GEOMETRID MOTHS. — The undersigned, desirous of perfecting as far as possible a monograph of the Geometrid moths, would beg the assistance of collectors, especially in the western and southern states, during the coming season. He would like information especially regarding the early stages, viz.: specimens and descriptions of the larva, chrysalis and their habits, as well as the food plants of any, even the most common species. Due credit will be given for any new facts. Out of about four hundred species in North America, we know of the caterpillars of but about twenty species. A number of illustrations[1] on the next page show the forms characteristic of this extensive family. The caterpillars are loopers or geometers, and are very familiar objects, feeding usually on low bushes and herbaceous plants late in summer.

As every species known is to be figured, it is hoped that entomologists will lend their rarities, and thus aid in the publication of what, it is hoped, will be a useful contribution to the study of our moths. To those aiding by the loan of over twenty specimens, a copy of the work will be sent. The larvæ can be reared easily; full instructions may be found in the "Directions for preserving and collecting Insects," recently published by the Smithsonian Institution, and which can be had on application to the subscriber.

Any moths of this family sent to the subscriber will be named and carefully returned if desired. The work is about ready for the press, and specimens are desired at once. The collecting season is May, June and July, in the middle and northern states, June being the month when they are most abundant. — A. S. PACKARD, Jr.

A DOUBLE HEADED LARVA OF A FLY.— Professor Weyenbergh of Cordova, La Plata, describes a double headed larva of Chironomus. The body seems double throughout, though the two heads begin to unite on the second segment behind the head, and become fully united on the sixth.

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[1] Most of the cuts are kindly loaned by Prof. F. V. Hayden, having been taken from his annual report for 1873 on the Geology of Colorado Territory.

Eufitchia ribearia.

Macaria Californiata.

Drepanodes varus, with larva and pupa.

Euaspilates spinataria.

Marmopteryx tessellata.

Aspilates 4-fasciaria.

Caulostoma occiduaria.

Anisopteryx vernata.

EXAMPLES OF GEOMETRID MOTHS.

INFLUENCE OF ELEVATION AND LATITUDE UPON THE DISTRIBUTION OF SPECIES.—It is surprising to what extent observers still overlook the fact of the influence of elevation upon the distribution of animal and vegetable life;—that they should still regard parallels of latitude, instead of isothermal lines, as bounding the habitats of species. That such is the case, however, is sufficiently apparent from such notices as that in the December NATURALIST, respecting the summer distribution of the chestnut-sided warbler (*Dendroica Pensylvanica*), which is but a sample of such remarks as frequently occur in reference to the distribution of our birds and mammals. The merest tyro in the study of the geographical distribution of animals knows that their range is not only determined by climatic influences, but that these influences depend largely upon the character of the surface of the country, as, for instance, whether it is a level plain or is broken by mountain ranges, and that increase in elevation is climatically equivalent to an increase in latitude. If authors would use isothermal lines in giving the distribution of a species, instead of arbitrary political divisions, they would be able to speak with much greater precision in such matters than is customary at present. The isotherms are now so well established, and a knowledge of them may be so easily acquired by means of our meteorological maps, that it seems quite time to adopt them in speaking of the distribution of species.

While southern New England may, generally speaking, form the southern limit of the breeding range of a bird, or of the distribution of a mammal, reptile or plant, the same species may, and generally does, exist in the highlands of the Alleghanies as far south as northern Georgia; and even species which occur only to the northward of southern Maine, in the lowlands, not only occur in the highlands of Berkshire county, Massachusetts, but also southward in the Alleghanies to North Carolina.

A great point will be gained in precision when naturalists come to use natural faunal areas, instead of arbitrary political divisions, in speaking of the distribution of species. If Dr. Brewer had said, in speaking of the chestnut-sided warbler, "*not known to breed south of the Alleghanian Fauna*," instead of "not known to breed farther south than Massachusetts," he would not only have expressed the fact with precision, so far as our present knowledge extends, but would have saved himself the exposure to such criticism as that made by Mr. Stark (Am. Nat., VIII, p. 756, Dec.,

1874). I mention the present case merely by way of illustration, and not for the purpose of making any special strictures upon my friend Dr. Brewer, who is by no means in this respect an exceptional transgressor. If it is urged that the people would not understand such expressions as the "Alleghanian Fauna," and the like, it may be said that the time has come when they should be familiar with them. Most intelligent people know that isothermal lines vary in direction with the elevation and contour of the land over which they pass, sweeping, in our own country, far to the southward in leaving the lowlands of the Atlantic coast; that they pass southward of the Appalachian Highlands, and then bend abruptly northward again along their western base. It is time they knew, also, that the different zones of animal life follow the flexures of the isotherms, and that there are natural faunal belts, sufficiently distinct to be capable of recognition, whose boundaries coincide very nearly with certain of these isotherms. Furthermore, that throughout eastern North America, at least, these faunal belts are already well known to specialists of the subject, and that there already exist definite expressions for such cases as the one that has furnished the text for the present note. I will add, also, that so much is already known of the laws of the geographical distribution of animal life, that one could have safely assumed, from our present knowledge of the general range of the chestnut-sided warbler, that from its being a rather common summer resident in southern New England, it would also be found to breed in the mountainous districts as far south even as northern Georgia.—J. A. Allen.

GEOLOGY AND PALEONTOLOGY.

New Order of Eocene Mammals.—At the last meeting of the Connecticut Academy, Feb. 17th, Professor O. C. Marsh made a communication on a new order of Eocene Mammals, for which he proposed the name *Tillodontia*. These animals are among the most remarkable yet discovered in American strata, and seem to combine characters of several distinct groups, viz.: Carnivores, Ungulates and Rodents. In *Tillotherium* Marsh, the type of the order, the skull has the same general form as in the bears, but in its structure resembles that of Ungulates. The molar teeth are of the ungulate type, the canines are small, and in each jaw there is a pair of large scalpriform incisors faced with enamel, and grow-

ing from persistent pulps, as in Rodents. The adult dentition is as follows: — Incisors $\frac{2}{2}$; canines $\frac{1}{1}$; premolars $\frac{3}{2}$; molars $\frac{3}{3}$. The articulation of the lower jaw with the skull corresponds to that in Ungulates. The posterior nares open behind the last upper molars. The brain was small, and somewhat convoluted. The skeleton most resembles that of Carnivores, especially the *Ursidæ*, but the scaphoid and lunar bones are not united, and there is a third trochanter on the femur. The radius and ulna, and the tibia and fibula are distinct. The feet are plantigrade, and each had five digits, all terminated with long, compressed and pointed, ungual phalanges, somewhat similar to those in the bears. The other genera of this order are less known, but all apparently had the same general characters. There are two distinct families, *Tillotheridæ*, in which the large incisors grew from persistent pulps, while the molars have roots; and the *Stylinodontidæ*, in which all the teeth are rootless. Some of the animals of this group were as large as a tapir. With *Hyrax* or the *Toxodontia* the present order appears to have no near affinities.

ANTHROPOLOGY.

CLAY-BALLS AS SLUNG SHOT OR COOKING STONES. — Round balls of clay as hard as that material could be made were seen in the museum of Nassau, N. P., labelled from a cave in the Islands. These might be used for two purposes, as they were round and the size of a hen's egg; first, their size and shape fitted them for a weapon of warfare, if wrapped in buckskin or hide drawn very tight over it and fastened, leaving a loose end, which, being firmly fastened over a strong stick, forms a formidable slung shot. The Apache Indians make and use the same kind of implement, which they use in battle, only their balls are of stone. The second use to which they might be applied is in cooking. After being heated very hot they were probably placed in the substance to be cooked, then taken out and this operation repeated until required no more. The ancient Indians of the Bahamas made pottery, as pieces found testify, therefore they could cook in vessels of pottery when stationary, but if travelling, it would be inconvenient to carry them, as they easily break; but they could make deep baskets, or trays of twigs, or leaves of the palm-trees so tight that they held water; thus, by putting water with whatever

was desired to cook, they would drop in these balls of clay red hot, and repeat the operation until the cooking was completed, without injury to the basket. There are several tribes of Indians in Arizona, New Mexico, Utah and California, which make water-tight baskets of willow twigs, and I have several times seen them cook by heating stones and dropping them into these baskets filled with the articles to be cooked. It might be urged against this mode of cooking, that it wasted the food, as so much must stick to the balls every time they were taken out. This would be true if they did not use their tongues to clean off all that adhered. Then if the mass were increased by a few ashes adhering to the balls, that would be nothing to them. Ashes were at least as healthy for them, as pepper and other condiments used by white men.—E. PALMER.

MICROSCOPY.

AMERICAN MICROSCOPICAL SOCIETIES.—The following list of Microscopical organizations is published to facilitate the work and increase the intercourse of the societies themselves, as well as of microscopists generally. Revised lists will be published from time to time, for which purpose secretaries and others interested are specially requested to furnish such corrections and additions as may become necessary.

AGASSIZ INSTITUTE, Sacramento, Cal. Organized 1874. *Secretary*, Rev. J. H. C. Bronte.

ACADEMY OF NATURAL SCIENCES, Philadelphia, Pennsylvania; Biological and Microscopical Section. Meets first Monday evening of month. *Director*, W. R. S. Ruschenburger, M. D.; *Vice-Director*, James Tyson, M. D.; *Recorder*, J. G. Richardson, M. D.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE; Microscopical Sub-Section. Meets occasionally in connection with the migratory sessions of the Association.

AMERICAN MICROSCOPICAL SOCIETY OF NEW YORK. Organized 1865. Meets second and fourth Tuesday evenings of the month. *President*, John B. Rich, M. D.; *Vice-President*, W. H. Atkinson, M. D.; *Secretary*, C. F. Cox, Port Richmond, Staten Island, N. Y.; *Treasurer*, Prof. T. L. Orenieu; *Curator*, Wm Dean.

BAILEY CLUB, New York City. A small club of working members. Meetings informal, every second Tuesday.

BOSTON MICROSCOPICAL SOCIETY. Organized 1873. Meets first and third Thursdays of month, at residences of members. *President*, L. M. Willis, M. D; *Vice-President*, I. J. Wetherbee, D. D. S.; *Secretary* and *Treasurer*, R. R. Andrews, M. D., Brattle Square, Cambridge, Mass.

BOSTON SOCIETY OF NATURAL HISTORY; Microscopical Section. *Committee*, E. Bicknell, R. C. Greenleaf, B. Joy Jeffries, M. D.

DARTMOUTH MICROSCOPICAL CLUB, Hanover, N. H. *President*, Prof. E. Phelps; *Vice-President*, Prof. L. B. Hall; *Cor. Secretary*, H. A. Cutting, Lunenburgh, Vt.

FAIRMOUNT MICROSCOPICAL SOCIETY of Philadelphia. Organized 1871. Meets monthly. *President*, F. F. Milne; *Secretary* and *Treasurer*, Wm. C. Stevenson, Jr., 24 South 4th St.

INDIANA MICROSCOPICAL SOCIETY, Indianapolis, Ind. Organized 1874. Meets first Friday evening of month. *President*, William B. Fletcher, M. D.; *Secretary* and *Treasurer*, E. Hadley, M. D., 191 Va. Ave.

KIRTLAND SOCIETY OF NATURAL HISTORY, Cleveland, Ohio; Microscopical Branch. *Secretary*, John Bowers.

LOUISVILLE MICROSCOPICAL SOCIETY. Louisville, Ky. Organized 1874. *President*, Prof. J. Lawrence Smith; *Vice-Presidents*. Noble Butler and C. F. Carpenter, M D ; *Treasurer*. C. J. F. Allen; *Secretary*, John Williamson; *Cor. Secretary*. E. S. Crosier, M. D.

MARYLAND ACADEMY OF SCIENCES, Baltimore, Md.; Section of Biology and Microscopy. Meets first and third Wednesday evenings of month. *Chairman*, Christopher Johnston, M. D.; *Secretary*, W. G. Harrison, M. D., 69 Centre St.

MEMPHIS MICROSCOPICAL SOCIETY, Memphis, Tenn. Organized 1874. Meets first and third Thursday evenings of month. *President*, S. P. Cutler, M. D.; *Secretary* and *Treasurer*, A. F. Dod, 257 Main St.

NEW JERSEY MICROSCOPICAL SOCIETY of the City of New Brunswick, N. J. Meets second Monday evening of month at Rutger's College. *President*, Prof. F. C. Van Dyck: *Rec. Secretary*, Rev. Sam'l Lockwood, Ph.D., Freehold, Monmouth Co., N. J.

PROVIDENCE FRANKLIN SOCIETY, Providence, R. I.; Microscopical Department. Organized 1874. *Chairman*, Prof. Eli W. Blake; *Secretary*, Prof. John Peirce, Post office box N. N.

SAN FRANCISCO MICROSCOPICAL SOCIETY, San Francisco, Cal. Organized 1872. Meets first and third Thursdays of month. *President*, Henry G. Hanks; *Vice-President*, Arthur B. Stout, M. D.; *Rec. Secretary*. C. Mason Kinne, 422 Cal. St.; *Cor. Secretary*. Henry C. Hyde; *Treasurer*, Chas. G. Ewing.

SOCIETY OF NATURAL SCIENCES, Buffalo, N. Y.; Microscopical Section. Organized 1872. *Curator*. Henry Mills, 162 Fargo Ave.

STATE MICROSCOPICAL SOCIETY OF ILLINOIS, Chicago, Ill. Organized 1869. Meets second and fourth Fridays of month. *President*, S. A. Briggs; *Cor. Secretary*. O. S. Westcott.

STATE MICROSCOPICAL SOCIETY OF MICHIGAN, Kalamazoo, Mich. *President*, Rev. Dr. Foster.

TROY SCIENTIFIC ASSOCIATION, Troy, N. Y.; Microscopical Section. Organized 1870. Meets monthly. *President*, R. H. Ward, M. D.; *Vice President*, Rev. A. B. Hervey; *Secretary*, Prof. Arthur W. Bower, 35 Seventh St.

TYNDAL ASSOCIATION. Columbus, Ohio; Microscopical Section. Organized 1874. *President*, Prof. Albert H. Tuttle; *Secretary*, C. Leo Mees; *Curator*, Rev. I. F. Stidham, 171 South 3d St.

NEW SLIT FOR TESTING ANGULAR APERTURE.—Believing Mr. Wenham's apparatus for this purpose to be unnecessarily complicated, Mr. Tolles has constructed a very simple substitute which is easily made and used. A piece of silvered glass mirror is cut to a convenient size (say 3x1), the silvered surface being protected by varnish so that it can be handled. Through the silvering a vertical slit is cut, the surface of the slit being cleaned by a little dilute acid. This slit may be as wide as the field of the highest power objective to be tested. A part of this slit is covered with a cover-glass under which and directly upon the slit are test diatoms, dry upon one portion of the covered part of the slit and balsam-mounted upon the rest, so that the slit can be used while tests of the definition of the objective are actually in view. If a high-angle objective be adjusted for the thickest cover it is capable of working through, and then tested upon the uncovered portion of this slit, the very great aberration will give a small and imperfectly defined angle; if then tested upon the covered portion of the slit, the definition is greatly improved and the angle largely increased. If now water or glycerine is introduced to make contact between the cover and the objective, definition becomes good, and the diatoms are exhibited on a well illuminated field, while the aperture, now an immersion angle, can be measured with the

proper appliances, such, for instance, as the semi-cylinder originally introduced for this purpose by Mr. Tolles.

A slit one-half or one-third as wide as the field gives equally good results where water-contact of the objective is used, but when working through air reduces the angle to an evidently fallacious degree. Glycerine is a better substitute for glass than water is, and therefore for a thin cover and an objective corrected for best work through thick covers, glycerine should always be preferred to water as the immersion-fluid.

"180°" Angular Aperture.—The latest contribution to this subject is a note from Mr. Wenham, which, besides its personalities, consists of a violent attack upon an article in the Naturalist for advocating "180°." As the article referred to simply mentioned the 180° as the claim of a certain optician, and did not say one word in favor of the propriety of the claim, the minor inaccuracies of Mr. Wenham's note may well pass uncorrected, while its sneering tone will be rated at its true worth by those who are familiar with the courtesies of literature and science. The treatment which Mr. Wenham has received from the Naturalist for years past is sufficiently well known.

Lest any future writer, rather than use a tiresome circumlocution, should unfortunately say 180° when he wished to say indefinitely near to 180°, it would be well to have it understood that no one need consider it either necessary or handsome to make such unguarded expression the occasion of an abusive reply.

Caps for Mounting Opaque Objects.—Prof. John Peirce of Providence, R. I., has had a die cut for making a novel kind of cell, which is excellent for mounting large opaque objects, such as many mineral specimens and nearly all seeds, which require to be permanently preserved and at the same time show best without a cover-glass. The cell is made of thin copper, and has the shape of a hat with a very low crown. The rim at the bottom is to be cemented with marine glue to the glass slide, and the top of the crown is a removable cap slipped on or off at pleasure, so that the object can be examined or manipulated with the greatest facility. Though not prepared for the trade, they could probably be obtained, in exchange or otherwise, by any microscopist.

Rogers' Micrometers and Test Plates.—Mr. Rogers of the Cambridge Observatory has made arrangements to furnish micros-

copists with samples of his fine ruling on glass which has been already noticed in the NATURALIST. The lines, which excel any with which we are familiar except the Nobert lines, are now ruled from $\frac{1}{100}$ to $\frac{1}{18000}$ inch, on glass slips 3 x 1, and covered with thin glass. They cost $8 or less, according to fineness.

THE ARGAND BURNER.—Microscopists who use illuminating gas with the common Argand burner will be interested in Mr. John H. Martin's suggestion of placing a thin piece of mica, with a small hole punched in its centre, upon the top of the glass chimney. A more perfect combustion of the carburetted hydrogen is secured, giving a very steady flame, and the full amount of light with the gas turned about half off.

MONOCHROMATIC SUNLIGHT.—Instead of a small disk of blue glass which has long been used in connection with a shutter or diaphragm or with some illuminating apparatus, Mr. J. E. Smith recommends a blue glass pane of about 12 x 18 inches, standing at the edge of the table, between the microscope and an open window through which the direct sunlight enters. The pane is supported by a cleat, so that it can be instantly placed in position or removed. The whole instrument stands in the blue light, and is managed exactly as with ordinary diffused daylight.

AMPHIPLEURA PELLUCIDA.—The latest measurement of the striæ of this favorite "test" is that of Prof. E. W. Morley, of Hudson, Ohio, communicated to the Memphis Microscopical Society, which estimates the markings at 92,600 to the linear inch.

NOTES.

PROFESSOR LUDWIG'S *Jubiläum* or the celebration of the twenty-fifth year of his professorship, took place at Leipzig, October 15. This eminent teacher, founder of the Saxon Physiologische Anstalt has in the past quarter of a century had more than a hundred and fifty private students, whom he has trained in special investigations, and of whom many have since become distinguished professors. There was a large assemblage of friends and pupils to take part in the ceremonies, including Professors Ernst Heinrich Weber, the Nestor of physiology; Helmholtz, Du Bois Reymond, and others of less fame from Upsala, Moscow, Edinburgh, Brussels, Vienna, etc. The oldest scholar proved to be Professor Fick,

of Zürich, and on him devolved the congratulatory address, at the conclusion of which a curtain fell, uncovering a bust of Professor Ludwig which had been made by Professor Schilling of Dresden. Professor Cyon, of St. Petersburg, spoke in behalf of Ludwig's Russian students, and the curtain fell again, displaying an exquisite silver clock. Professor Müller presented an album with photographs of all his pupils. But the finest of possible gifts was the superb volume of sixteen memoirs on anatomy and physiology which had been prepared as a lasting commemoration of the day. Then followed addresses from former colleagues in Zürich and Vienna, and presentations of memoirs dedicated to Ludwig and sent by various learned societies. In the afternoon the company assembled again in the Hôtel Hauffe for a dinner given to the Professor, at which there was more speech-making. "I am an old man," said Weber in private conversation, "but I have never seen or heard of so much honor being done to any professor. It has never happened (*Es ist nie dagewesen*)." In the evening, at Professor Ludwig's own house, the guests found fifty congratulatory telegrams spread upon the table, which had been sent from the principal towns of every part of Europe.—*Nation.*

The trustees of the Peabody Museum of Yale College,—Professors James D. Dana, Benjamin Silliman, George J. Brush and Othniel C. Marsh, Gov. Ingersoll, Hon. R. C. Winthrop, and G. P. Wetmore,—have decided to proceed to the immediate erection of one wing of the building, at a cost of $160,000. The lot on which it is to stand extends from Elm to Library streets, being one hundred and forty-five feet deep, and four hundred and fourteen feet in length. The front of the entire building will extend three hundred and fifty feet on High street. The wing to be erected at this time will have a front of one hundred fifteen feet on High, and one hundred feet on Elm streets, and will contain three stories with a high basement. The basement will contain working rooms, and fossil foot-prints; the first main story, a lecture room and mineralogical specimens; the second story, geology, especially fossil vertebrates; the third story, zoological specimens; the attic, archæological and ethnological specimens. The mineralogical collection of the Museum is to be under the charge of Professor G. J. Brush, the geological department under Professor O. C. Marsh, and the zoological under Professor A. E. Ver-

rill. The original gift of Mr. Peabody was $150,000, with the provision that a fire-proof building be erected, and $50,000 kept as a reserve fund. In accordance with the terms of the gift, the land is to be given by the college, and the building, when completed, is to be the property of the college. A building fund has been reserved which will not be used until it amounts to at least $100,000.

Sir Charles Lyell, the eminent geologist, died Feb. 22, at the age of seventy-seven. He was born Nov. 14, 1797. He began to publish geological papers in 1826. In 1830 appeared his "Principles of Geology." This work was original in its method, as the author sought to explain past geological events by laws in operation at the present time. The doctrine is called Uniformitarianism, and is of a piece with Darwinism and evolution. Lyell in a measure was to geology what Darwin is to biology.

Sir Charles Lyell visited this country in 1841. His journey resulted in the publication of "Travels in North America in 1841–2." "A Second Visit to the United States" appeared in 1849. His "Geological Evidences of the Antiquity of Man" was published in 1863, in which he endorsed the theory of Mr. Darwin, though previously opposed to the development hypothesis, which his whole course of geological thought had unconsciously perhaps to himself favored.

The Cornell University has just received from Australia, through Prof. H. A. Ward, a fœtal Dugong (*Halicore australis*), about 2½ feet long, well preserved in salt. The intestines had been removed, but the other viscera, including the peculiar bifid heart, are in good condition.

It is my hope that its dissection may throw some light upon the general homology of the pectoral muscles with mammals; and that its brain and other organs may lend some aid to our knowledge of the relations of this peculiar group of aquatic Herbivora. — Burt G. Wilder.

The Newark (New Jersey) Scientific Association was organized in January last, with the following officers:—President, Dr. A. M. Edwards; Vice President, Dr. A. N. Dougherty; Secretary, G. J. Hagar; Treasurer, W. S. Nichols. The Association will hold monthly meetings, give lectures and form a cabinet. It intends to pay special attention to local natural history, and do what it

can in promoting science in Newark and vicinity. We are glad to see these new societies come into existence, and hope that every city and town in the country will soon have its scientific society.

We have been requested by the author to state that the Congressional edition of Capt. W. A. Jones' report on his reconnaissance of N. W. Wyoming, in 1873, contains only one-half of Mr. T. B. Comstock's geological report. The copies ordered for the use of the Engineer Office in Washington (to be published as soon as possible) will contain seven more chapters, with twenty-nine additional cuts. The forthcoming portion will be more valuable than the eight chapters already published.

"The Natural History Association of North Western College," at Naperville, Illinois, has recently completed its organization. The following are the officers:—J. L. Rocky, President, A. Goldspohn, Vice President, J. W. Troeger, Secretary, C. F. Rassweiler, A. M., Treasurer, Prof. H. H. Rassweiler, Curator, Miss N. Cunningham, Directress of the Botanical Department, C. H. Dreisbach, Director of the Mineralogical, and J. W. Troeger of the Zoological.

The "Dunkirk Microscopical Society" was organized in June last and now consists of thirteen members. Its officers are Prof. J. W. Armstrong, D. D., President, and Geo. E. Blackham, M.D., Vice President, Treasurer and Secretary. Its regular meetings are held on the second Friday of each month.

A Fungus show has been held at Munich, in the Crystal Palace there, from October 3rd to 11th, and is said to have been visited by nearly 50,000 persons. The arrangements were well made and the plants carefully labelled. A list of the species exhibited will be found in the "Gardener's Chronicle."

The Memphis Microscopical Society, organized last summer, with a membership at the outset of about thirty, is doing good work. At least one paper of considerable importance has been read at its monthly meetings. Papers or specimens are earnestly desired, in order to add to the interest of the meetings.

A society for the promotion of science and history was formed in November last under the title of the Central Ohio Scientific Association, at Urbana, Ohio. Theo. N. Glover is the president and Thos. F. Moses the corresponding secretary.

DR. GIDEON LINCECUM, of Long Point, Texas, died November 28, 1874, of paralysis. He was a valued contributor to this journal, and his papers showed keen powers of observation. His most remarkable contributions were on the agricultural ants of Texas.

CHARLES KINGSLEY, reformer, novelist, poet and naturalist, died Jan. 25, aged fifty-five. His "Glaucus, or Wonders of the Shore," is one of the most inspiring popular science books ever written, and evinced the hearty love of science of its gifted author.

THE plants collected in Florida by Dr. E. Palmer, have been named by Prof. Gray and Mr. Watson. They are made into sets and are for sale. Apply to Prof. Asa Gray, Botanical Garden, Cambridge, Mass.

A GERMAN society in Japan has issued its first volume of Proceedings, containing a notice of a cuttle fish (*Ommastrephes*) fourteen feet in length, captured on the coast of Japan.—*Monthly Microscopical Journal.*

DR. R. E. GRANT, the anatomist, best known for his studies on the sponges, died in London, August 23.

EXCHANGES.

The Memphis Microscopical Society is prepared to offer exchanges of unmounted microscopic objects. Lists furnished by A. F. Dod, Sec'y, 257 Main St., Memphis, Tenn.

BOOKS RECEIVED.

The Common Frog. By St. George Mivart. Macmillan & Co. London, 1874. Nature Series. Illustrated. pp. 158. 8vo. Price $1.00.

Archiv fur Anthropologie. Zeitschrift fur Naturgeschichte und Urgeschichte des Menschen. Braunschweig. 1874.

Notice sur l'Empire du Japon. Yokohama, 1873. pp. 85. 8vo.

Special-Catalog der chinesischen Ausstellung. III Abtheilung. Wien, 1873. pp. 49. 8vo.

Das Winkler'sche Taschen-Dendrometer. By Franz Grossbauer. Wien, 1874. pp. 144. 8vo.

La Retraite de Laguna. By Alfred D'Escragnolle Taunay. Rio Janeiro, 1871. pp. 224. 8vo.

Die Œsterreichischen Alpenlænder und ihre Forste. By Joseph Wessely. Wien, 1853. pp. 809. 8vo.

Die Lehre vom Dunger. By Emil Kirchof. Wien, 1872. pp. 336. 8vo.

Die Forstwirthschaftslehre fur Forstmanner und Waldbesiker. By Leopold Grabner. Wien, 1856. pp. 290. 8vo.

Das Rechnungswesen fur forster oder forstverwaltungen. By Agnaz Maur. Wien, 1859. Dritte vermehrte Auflage. pp. 345. 8vo.

Die Lehrforste der Eisenacher Forstschule: Eisenach, Wilhelmsthal, Ruhla. By Carl Grebe. Gisenach, 1858. pp. 74. 8vo.

Compendium der Jagdunde. By Christof Liebich. Wien, 1855. Illustrated. pp. 360. 8vo.

Notions on the Chorography of Brazil. By Joaquim Manoel de Macedo. Translated by H. Le Sage. Leipzig, 1873. pp. 576. 8vo.

Der Buchen-Hochwaldbetrieb. By Carl Grebe. Gisenach, 1856. pp. 236. 8vo.

Die Beaufsichtigung der Privatwaldungen von Seiten des Staates. By C. F. A. Grebe. Gisenach, 1845. pp. 139. 8vo.

Die Industrie des Konigreichs Wurttemberg. Prag, 1873. pp. 111. 8vo.

Schweizerischer Katalog. Wien, 1873. With charts. pp. 295. 8vo.

Verzeichniss der Producte, welche die landwirthschaftliche Gesellschaft von Santiago de Chili zur Wiener Weltausstellung abgesandt hat. Wien, 1873. pp. 11. 8vo.

Leitfaden fur den Unterricht und die Prufung. Wien, 1861. With cuts. pp. 326. 8vo.

Conference Sanitaire Internationale a Vienne, 1874. With chart. pp. 561. 4to.

Schematismus und Statistik du Staatsforste. By Karl Schindler. Wien, 1864. pp. 214. 8vo.
Einrichtung des Forstdienstes in Oesterreich. By J. Wessely. Wien, 1866. pp. 807. 8vo.
Rationelle Zucht der Susswasserfische. By Raphael Molin. Wien, 1864. pp. 346. 8vo.
Forstbenakung. By G. Konig. Eisenach, 1861. pp. 431. 8vo.
Holzexport Oesterreichs. By A. F. v. Hohenbruck. Wien, 1869. pp. 303. 8vo.
Lehrbuch der forstlichen Zoologie. By F. M. Eduard Opel. Wien, 1869. pp. 483. 8vo.
Annales de la Societe Entomologique de Belgique. Bruxelles, 1873. pp. 431. 8vo.
Proceedings of the Zoological Society of London, 1874. Part II. pp. 153-248. Part III. pp. 249-488. 8vo.
Diptera, or two-winged Flies. Manuscript Notes from my Journal, or Illustrations of Insects, Native and Foreign. By Townend Glover. Washington, D. C., 1874. pp. 120. 4to.
Babbitt Portfolio. New England Society of Orange, New Jersey. October, 1874. 4to.
Polarization of Light. Nature Series. By William Spottiswoode. London, 1874. pp. 128. 8vo. $1.00.
Chemical and Geological Essays. By T. Sterry Hunt. Boston, 1875. p. 489. 8vo. J. R. Osgood & Co. $3.00.
Tables for the Determination of Minerals. By Persifer Frazer, Jr. Philadelphia, 1875. pp. 117. 8vo.
Researches in Acoustics. From the American Journal of Science and Arts, vol. viii, 1874. By Alfred M. Mayer. Paper No 5. pp. 42.
Discrepancies between Theory and Observations of the Moon's Motions. Trans. Kansas Acad. of Sciences, 1874. By F. W. Bardwell. p. 4. 8vo.
Index to vol. I to xiii Observations on the Genus Unio. By Isaac Lea. Philadelphia, 1874. vol. iii. pp. 29. 4to.
Report of the Commissioner for 1872 *and* 1873. U. S. Commission of Fish and Fisheries. Washington, 1874. Part II. pp. 98. 8vo.
Report of the Geological Survey of the State of Missouri, including Field Work of 1873-1874. With atlas. By Garland C. Brodhead. Jefferson City, 1874. pp. 783. 8vo.
Report upon Vertebrate Fossils discovered in New Mexico, with descriptions of New Species. Engineer Department, U. S. Army. By Prof. E. D. Cope. Washington, 1874. pp. 18. 8vo.
Bericht uber die Thatigkeit der St. Gallischen, 1872-73. St. Gallen, 1874. pp. 522. 8vo.
Bulletin Mensuel de la Societe d'Acclimatation. Paris, 1874. 3me Serie, Tome I. Nos. 7, 8. pp. 433-544. 8vo.
Sitzungsberichte der philosophisch-philologischen und historischen Classe der k. b Academie der Wissenschaften. Munchen, 1873. Heft v, vi. pp. 599-912. 1874. Heft i-iii. pp. 132-372. 8vo.
Sitzungsberichte der Mathematisch-physikalischen Classe der k. b. Akademie der Wissenschaften. Munchen. 1873. Heft iii. pp. 274-344. 1874. Heft i-ii. pp. 240. 8vo.
Uber Deutschlands Weltstellung. Franz Von Loher. Munchen, 1874. pp. 48. 8vo.
Dr. Justus Freiherrn von Liebig zum Gedachtniss. Max von Pettenkofer. Munchen, 1874. pp. 50. 4to.
Gedachtniss-Rede auf Konig Johann von Sachsen. J. von Dollinger. Munchen, 1874. pp 16. 4to
Ueber den Einfluss des Freiherrn Justus von Liebig auf die Entwicklung der Physiologie. Theodore L. W. von Bischoff. Munchen, 1874. Eine Denkschrift. pp. 103. 4to.
Justus Freiherr von Liebig als Begrunder der Agrikultur-Chemie. August Vogel. Munchen, 1874. Eine Denkschrift. pp. 61. 4to.
The Species of the Lepidopterous Genus Pamphila. By Samuel H. Scudder. Memoirs Bost. Soc. Nat. Hist., vol. ii. part iii, No 4. Boston, 1874. pp. 341-353. 4to.
Annual Report upon the Geographical Explorations and Surveys West of the One Hundredth Meridian. By George M. Wheeler. Washington, 1874. pp. 130. 8vo.
Elementary Collection of Minerals and Rocks. By E. Seymour. New York, 1874. pp. 37. 8vo.
Natural History, No. 1. On the Muridæ. U. S Northern Boundary Commission. By Elliot Coues. Philadelphia, 1874. pp. 28. 8vo.
New Species of North American Noctuidæ. By Aug. R. Grote. Philadelphia. pp. 17. 8vo. Received Nov. 19, 1874.
Chemical and Geological Essays. By T. Sterry Hunt. Boston, 1875. p. 501. 8vo. cloth. Price $3 00.
Un mot sur le mode d' adherence des males de Dytiscides aux femelles pendant l'acte de l'accouplement. Par Felix Plateau. Gand, 1872. pp. 8. 8vo.
Un parasite de Cheiropteres de Belgique. Par Felix Plateau. Extrait des Bulletins de l'Academie Royale de Belgique. Bruxelles, 1873. pp. 3. 8vo.
Studies on the Facial Region. By Harrison Allen. Philadelphia, 1875. Reprinted from the "Dental Cosmos." pp. 117. 8vo.
Note sur un procede pour donner ou pour rendre leur couleur rouge aux muscles conserves dans l'alcohol. Par Felix Plateau. Bruxelles, 1874. pp. 7. 8vo.
Constitution, By-laws, etc., of the Troy Scientific Association. Troy, 1875. pp. 11. 8vo.
Preliminary Report upon Invertebrate Fossils collected by the Expeditions of 1871, 1872 *and* 1873, *with Descriptions of New Species.* By C. A. White. Washington. 1874. Geographical and Geological Explorations and Surveys West of the 100th Meridian. pp 27. 8vo.
Notes on the Natural History of Portions of Montana and Dakota. By J. A. Allen. Boston, 1874. pp. 61. 8vo.
Bulletin of the Torrey Botanical Club. New York. Vol. v, Nos. 10 and 12, Vol. vi, No. 1. Index to Vols. i-v. (With photograph of Dr. Torrey.) 8vo.
Principles of Metal Mining. By J. H. Collins. G. P. Putnam's Sons. New York, 1874. Illustrated. pp. 149. 12mo. Price .75.
Magnetism and Electricity. By John Angell. G. P. Putnam's Sons. New York, 1874. Illustrated. pp. 176. 12mo.
On British Wild Flowers considered in Relation to Insects. By Sir John Lubbock. London. McMillan & Co. 1875. Nature Series. Illustrated. pp. 186. 8vo. Price $1,50.
Lists of Elevations principally in that portion of the United States west of the Mississippi River. Washington, 1875. Hayden's Geological Survey of the Territories. Miscellaneous publications. No. 1. pp. 72. 8vo.
Notice of the Chemical and Geological Essays of T S Hunt. By James D. Dana. From Am. Jour. Sci. and Arts. Vol. ix, Feb., 1875. pp. 102-106. 8vo.
Notice of New Tertiary Mammals, IV. By O. C. Marsh. From the Am. Jour. Science and Arts, March, 1875.) Received February 28, 1875.

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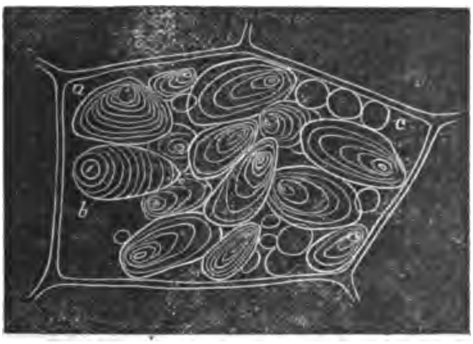
ABOUT STARCH.

BY PROF. M. W. HARRINGTON.

PERHAPS it would be more correct to have our title read "About Starches," for each species of the higher plants seems to have its own characteristic and recognizable sort of starch.

One of the most easily recognizable sorts of all is the starch from the potato. It is very easily got at, too, and requires little

Fig. 72.



or no preparation for its examination. Take a fresh potato and cutting it open, take the thinnest possible slice which one can make with a sharp razor. Deposit the slice on a glass-slip, drop a little water on it, cover it with a thin glass, and it is ready for examination.

Placing the specimen now under the microscope — a magnifying power of 250 diameters does very well — we see (Fig. 72) an im-

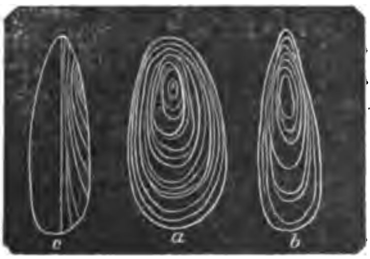
mense number of bodies of two sorts. The most striking are ovoid bodies of considerable apparent size, often showing a series of eccentric rings, the one within the other. Sometimes the rings are seen to be arranged about a dark point or nucleus. Mixed in with these ovoid bodies are large numbers of much smaller disk-shaped ones, without apparent rings. These two sorts of bodies are the starch granules of the potato. It is no unusual thing to find two pretty distinct sizes of starch grains in the same plant. There are intermediate forms of all sizes, but the two sizes referred to so much predominate as to strike the attention at once. The grains are packed in very closely together in much larger cells the cut edges of which can be distinguished, although they are very transparent. Here and there in the section are spots without starch grains and with much finer tissue. These are sections of the vascular bundles where longer and fibre-like cells and vessels which arise from the stem pass through the tuber. Toward the edge of the potato, too, the starch grains are seen to grow less numerous and the cells smaller with thicker walls.

To render the position of starch and cell-walls still more evident, let us apply a little of the aqueous solution of iodine to the specimen. This can be readily done by placing a drop at the edge of the thin glass cover. It will be gradually drawn under to mingle with the water. Meantime its progress and its effect can be watched with the eye at the microscope. Should the iodine not pass readily under the glass cover, its progress can be hastened by placing a bit of blotting paper in contact with the cover on the other side. As it absorbs the water, the iodine will pass in to supply its place. As the iodine comes in contact with the cell-walls they are stained a rich gold-color. At the same time, a series of changes is taking place in the starch. The grains were at first colorless and transparent; as the iodine reaches them, they are stained, first yellow, then red, violet, blue, and finally an opaque black blue, if the iodine is strong enough. Here we have the cell-walls colored one tint, and the starch another, and it is very easy to determine their relative positions.

The use of iodine is the most usual test for starch, and the resulting blue color is just as certain in the blue grains under the microscope as in the starch-paste in use by chemists. If sulphuric acid is added to the specimen, the cell-walls gradually turn blue too.

We have now the position, the general appearance and the usual test for starch. Let us examine it more carefully to see what its structure is. For this purpose take a very little matter scraped from the cut surface of the potato; aim to get only starch and none of the cell-structure. Place this on a clean glass slide, add a drop of water and put on a thin glass cover as before. By careful management of the light, we can probably now see the concentric rings quite plainly. They have the shape of the outline of the starch-grain. If it is egg-shaped, as is usually the case, so are they. If it is almost triangular or linear, as sometimes happens, so are the concentric rings. These rings are sometimes easily seen; at others, only considerable care can bring them out. I have sometimes found them plainer in the starch from a sprouting potato than from others. In potatoes frozen and thawed, they

Fig. 73.



appear distinct. If they can be brought out in no other way, the application of dilute chromic acid will usually show them very plainly. A few lines, scattered among the rest, are generally plainest.

Are these lines simple markings on the surface of the grains, or are they edges of layers one inside the other? In order to ascertain that we must roll them over and see how they look on the edge or on the other side. This is easily done. We have only to incline the body of the microscope a little more, and some of the grains will be carried down by the action of gravity, and will roll over with more or less freedom. If this does not serve, we can press on one edge of the thin cover with the point of a pencil, and a great commotion will be caused among the grains. As this subsides, we can watch some of them rolling over leisurely, now stopping for a moment on the face to give us an opportunity to examine that side, then rolling up on edge and hesitating there

while we survey that side too. Now if the lines are on the surface, a grain like *a* (fig. 73) would look like *b* when rolled up on its side. If, on the other hand, these rings mark the edges of concentric layers, coats arranged like the coats of an onion, they would be arranged in the edge view of the grain essentially as they are in the side view. As the grains roll over, we see very distinctly the rings are concentric yet; the starch grain must be composed of layers one over the other.

If we take a little of the starch from the potato and dry it, without the addition of water, at a temperature of perhaps 150°, we shall see a dark point appearing at one end — usually the smaller. This is the nucleus and around it are arranged the concentric rings already mentioned. It has been described as a little pedicle or stem by which the starch-grain is attached to the cell-wall. This was when it was still thought that the grains budded out from the wall, a theory completely disproven now, by what is known of the development and functions of the wall, as well as by specific observations on the formation of the grains themselves. The nuclei have been described too as holes, passing into the interior from the outside, and admitting the materials from which the successive layers were formed from without inwards. If the development of the starch-grain were endogenous, there might be some ground for this hole-theory of the nucleus, but it is now well proven that their formation is from within out, or exogenous. There is no easily accessible specimen at this season of the year, to illustrate this, but writers generally refer to ripening corn, where all the stages can sometimes be seen in a single grain. However, we can easily prove with the specimens under examination that the nucleus is neither a little stem nor a canal. If it were either, it would appear, as we roll the grains, sometimes elongated. As we roll the grains over, by inclination of the stage, or pressure from one side, as before, we see no difference in the shape of the nucleus. It is the same round or angular black spot, occupying the same position from whatever point it is viewed. If we are lucky, we may get a grain up on end, and examine it in the direction of its long diameter. The position of the nucleus and arrangement of the rings remain the same.

What can we conclude concerning the nature of the nucleus from this? It was indistinctly or not at all visible in the fresh grain; it becomes visible on drying, and looks like an air space.

It is in the structural centre of the grain. If the drying is carried far enough, cracks may be seen extending from the nucleus. They generally radiate, looking something like a star. Sometimes one long crack runs the greater part of the length of the grain. The cracks may and may not reach the surface. Taking all these facts together we can draw the fair conclusion; that the layers differ in density; that the inner layers are softer than the outer, because they contain successively more water; that the water is driven off by the heat and the consequent vacuity appears, forming the "nucleus," where there is most water, that is, in the innermost layers; that farther drying causes cracks to appear in the harder layers, the longer the drying the more extensive the cracks.

Further evidence in favor of this explanation of the starch-grain is afforded by the action of hot water and chemicals. If a little starch is boiled, the grains swell, burst and emit much glairy matter. At the same time a thin pellicle sinks to the bottom and is only gradually absorbed. These phenomena can be partially seen in a test-tube. They can be watched under the microscope if the observer has the apparatus for heating his slide without injuring his objectives. For those who are without this apparatus, perhaps the best way is to deposit a little starch with two or three drops of water on a glass slide, and then boil the water down without the application of too much heat. The slide should be allowed to cool before it is placed under the microscope. Starch can then be seen arrested in every stage of solution. One is apparently untouched; another is slightly swelled; another is much swelled at one end; still another is just ready to burst.

A similar series of phenomena can be seen by the application of caustic potash. Arrange a slide as before, for the application of iodine and treat in the same manner. The approach of the reagent causes a great commotion among the starch grains. They become uneasy, dance about, and finally sweep away to the other side of their limits. To see the action of the potash well, one must select a field easily accessible to the reagent, but where the exit of the grains is prevented by an air-bubble or bit of tissue just behind them. That being the case, the grains advise the observer of the approach of the potash by becoming very uneasy. As it strikes them they begin to swell, the swelling extending down their length as the potash advances. The swelling is mostly lateral, and what was an ovoid body before becomes a broad disk.

Meantime the grains warp and twist and writhe about. Separated before by considerable spaces, they now block up the whole field, and their outlines gradually disappear until the whole is a homogeneous mass.

The action of sulphuric acid differs a little. There is the same uneasiness of the grains on the approach of the acid. Meantime the concentric lines grow very sharp and distinct. When struck by the acid, the grains swell until nearly globular, then a fissure appears, generally in the vicinity of the nucleus. The grain is rent from side to side, and a mass of liquid matter with some grains intermixed, shoots out with so much force that it is sometimes carried to a distance of two or three times the diameter of the grain.

From these observations it appears evident: that the outer layers are more dense than the inner; that the semi-liquid interior absorbs water or other fluids by endosmose until the exterior is so much expanded as generally to burst; that the outer layers are much less readily dissolved than the inner.

The use of the polarizing apparatus shows in a striking and beautiful manner that the nucleus coincides with the optical centre of the grain — which might be translated that the layers are really regularly arranged around the nucleus. It also brings out more clearly the rings themselves. If abundance of light is used, and a plate of selenite is inserted between the object and the analyzer, a cross of colors of rare beauty is seen on the grains. If the polarizer is now rotated, the play of colors is very beautiful. The interesting fact to us, however, is that the arms of the color-cross meet at the nucleus.

We have thus seen that the starch grain is an organized body, composed of layers arranged about an eccentric focus, and that these layers increase in density from within out, the innermost being comparatively soft.

BOTANICAL OBSERVATIONS IN SOUTHERN UTAH.

BY C. C. PARRY.

No. 3.

When exposed to the withering summer heat of 105° to 110° F. in the valley of the Virgen, it was tantalizing to see within twenty miles to the north the rugged slopes of Pine Mountain streaked with patches of snow. Having secured most of the lowland and desert plants, I was anxious to supplement my collection with the alpine flora of the adjoining high mountain districts. Accordingly, on the 8th of June, I undertook an excursion to Pine valley, occupying an extensive basin on the northwest slope of Pine Mountain, thirty miles by the travelled road from St. George. Our route, which if practicable would have followed up the valley of the Santa Clara to its extreme sources, mounted by a series of very steep ascents to the abrupt sandstone ridges bounding the valley on the left. Higher up the rugged features of the bald uplands are greatly exaggerated by a confused intermingling of sedimentary and igneous rocks. Recent volcanic overflows had partly filled up the denuded sandstone ravines, with floods of black, scoriaceous lava. Some distance farther on the source of these igneous products is brought to view in two distinct volcanic cones, with clearly defined craters. The course of the Santa Clara through this confused labyrinth of aqueous and igneous deposits, is completely hid from view in inaccessible chasms. At a considerable elevation towards the foot-hills of Pine Mountain, there is a stretch of comparatively level country, scantily watered by irregular snow-fed streams, known as Damaran Valley. Here the polymorphous evergreen shrub oak (*Quercus undulata* Torr.) makes its appearance associated with the still more spiny-leaved Barberry (*Berberis Fremontii* Torr.). Occasionally in strongly impregnated saline soil, was noticed a broad leaved Lycium, the species of which, on account of the absence of flower or fruit, could not be satisfactorily determined.

Frequent along the roadside was an old Californian acquaintance, *Platystemon Californicum* Benth. (No. 8), not heretofore known east of the Sierra Nevada, and as if to keep up the distant

association there were occasionally extensive patches of *Emmenanthe penduliflora* Benth. (No. 175). In our noon halt under the shelter of a wagon-bed, it was quite refreshing to be able to gather an abundance of *Gilia filifolia* Nutt. (No. 195) and *Centrostegia Thurberi* Gray (No. 232), without necessary exposure to the hot sun. In crossing over the prolonged spurs of the mountain range to reach the northwestern slope of Pine mountain, we encounter a growth of clumpy cedars, in the shelter of which were found scattering plants of the *Frasera albo-marginata* Watson (No. 203) only known before from scanty specimens collected by Dr. Palmer in this same section in 1870. In similar gravelly stretches we also find *Caulanthus crassicaulis* Watson, *Physaria Newberryi* Gray, and *Thelesperma subsimplicifolium* Gray (No. 108). Quite conspicuous along the borders of rivulets and moist springy places, occurred the showy-flowered *Pentstemon Palmeri* Gray, lately extensively introduced into gardens from seed distributed by Mr. A. L. Siler.

Our upward route occasionally crossing the clear dashing stream of the Santa Clara along its upper course, finally emerged into the wide open basin of Pine valley, lying at the base of steep mountain ridges heavily timbered with pine and spruce. The regular outlines of this basin at once indicate it as the bed of an ancient lake, since drained through the deep gash through which the Santa Clara courses to mingle its tribute of melting snow with the turbid waters of the Virgen. The atmospheric coolness of this elevated district afforded a refreshing contrast with the torrid heat of the lowlands, and was especially noticeable in the vegetation, which exhibited a more northern aspect. In the cultivated fields the difference was equally striking; wheat then ready for harvest at the mouth of the Santa Clara, was just spreading out its early leaves at its upper sources; cotton-woods which several weeks before had opened their bolls in St. George, were barely in bud at Pine valley. In fact the flowering season in these elevated districts was only just commenced, and the bald alpine ridges toward the summit of the range showed no signs of advancing vegetation, being still occupied by scattered snow drifts. Under these circumstances only the lower slopes afforded scope for botanizing during the short stay devoted to this section.

Disagreeably abundant in all the foot-hills, as a serious impediment to comfortable travelling, is the deciduous leaved shrub oak

(*Quercus undulata* Torr. var. *Gunnisoni* Engel. ined.). Much more attractive with its glossy foliage and long feathery seeds, is the mountain mahogany, *Cercocarpus ledifolius* Nutt. (No. 58), which here attains the dimensions of a small tree often twenty feet in height, with trunks six to eight inches in diameter. Along the borders of all the numerous mountain streams the common alder (*Alnus incana* var. *glauca*) is abundant, associated as elsewhere in the Rocky Mountain districts with *Betula occidentalis* Hook. As if to complete on a small scale the resemblance with analogous eastern sections, the western sugar maple (*Acer grandidentatum* Nutt.) makes its appearance. Though generally of a low bushy growth, it occasionally attains the size of a small tree, with trunks a foot or more in diameter. The wood in hand specimens is undistinguishable from our hard maple, and is applied to similar uses. The Coniferæ of this section include, on the lower slopes extending down into the valley, large trees of *Pinus ponderosa* and *Abies Douglasii*, succeeded higher up by scattering growths of *Pinus flexilis* and *Abies concolor*, and towards the summit by dense forests of *Abies Engelmanni*. The highest elevation is at no point sufficient to show a well-defined timber line, though bare alpine patches are spread out at various exposed points near the summit of the range. The lower dividing ridge to the north and west is mainly occupied by a scattering growth of cedar, the undergrowth affording the following plants, viz.: *Physaria Newberryi* Gray (No. 14), *Pachystima myrsinites* Raf., *Astragalus atratus* Watson (No. 47), *Hymenopappus luteus* Nutt. (No. 107), *Gilia aggregata* var. *Bridgesii* (No. 194), *Echinospermum deflexum* Lehn. (No. 172).

In the upper portion of the main valley was found a very neat species of Trifolium with large reflexed heads, *Trifolium Bolanderi* Gray (No. 34). Near by on the borders of a springy bog occurred in great abundance the interesting *Lewisia Brachycalyx* Engel. (No. 22). This rare species, only known heretofore by a few imperfect fragments, will be characterized anew by Dr. Engelmann in the accompanying list. Though much inferior in beauty to the northern typical species (*Lewisia rediviva* Ph.), it still presents the same style of flower and foliage on a somewhat smaller scale, and being undoubtedly hardy, may be improved by cultivation. Some of the more familiar aspects of the sub-alpine flora were presented in the well known Rocky Mountain forms of *Aqui-*

legia cœrulea Torr., *Mertensia sibirica* Don., and *Polemonium humile* Willd. It would have been interesting later in the season to have made a more thorough examination of the high alpine exposures, which from their isolated position would doubtless afford rare or new species. The exchange from the cool snow-drifts of Pine mountain to the oven heat of St. George proved much less pleasant than the reverse process, though more easily accomplished. It is worthy of remark in this connection to note the mutual dependence of these two strongly contrasted but adjoining districts. Thus the moisture, condensed either in the form of summer rain or winter snow on these high mountain ridges, is not all exposed in open water courses to be directly returned to the atmosphere by the intense evaporation of the lower desert tracts. A large part of it sinks into the pervious sandstone strata, dipping towards the south, thence working its way through deep unseen channels, it breaks out in the form of copious springs at the base of the high cliffs bounding the Valley of the Virgen. From this source is derived the necessary supplies of irrigating water for the gardens of Washington and St. George. In return, these semi-tropical districts contribute to the dwellers in the mountains the elaborated products of the choicest garden fruits that would be otherwise unattainable. Without such a mutual exchange neither of these sections would be as well adapted as now for civilized habitation.

On the 25th of June having completed my botanical collection in the valley of the Virgen, I left on my return route to Salt Lake, having arranged to spend a few weeks in the more elevated districts within the rim of the great basin.

On reaching Cedar city, sixty miles to the north of St. George, in the latter part of June, it was not very encouraging to note that the continued dry season had in a great measure completed the development of the early Spring plants, which were but scantily succeeded by later summer forms. On the rocky and variegated marly exposures adjoining the town, the conditions seemed especially favorable for a peculiar flora, and this expectation was in a measure realized, though in scanty forms. Among these is a well marked new species of Gaillardia characterized by Prof. Gray as *Gaillardia acaulis* n. sp. (No 120).

Here also occurred quite abundantly a species of *Lepidium* near to *Lepidium integrifolium* Nutt., or possibly a new species (No. 16).

Other rarities include *Polygala subspinosa* Watson (No. 32), *Brickellia linifolia* D. C. Eaton (No. 89) and *Eriogonum villiflorum* Gray (No. 243). On one of the exposed rocky slopes was gathered a dwarfed variety of *Cercocarpus ledifolius* Nutt., or possibly a new species to which the name of *Cercocarpus intricatus* n. sp. (No. 59) may be provisionally applied. Along the gravelly margins of Cedar Creek was found *Astragalus Sonoræ* Gray (No. 53), *Astragalus longocarpus* Gray (No. 52) *Thelesperma subnudum* Gray, n. sp. (No. 109) and *Lygodesmia grandiflora* Gray (No. 128). On shaded hill-sides, *Cercocarpus ledifolius* Nutt., *Cowania Mexicana* Don. and *Fraxinus anomala* Torr. (No. 210), are abundant. Having soon exhausted this scanty flora, my attention was directed to the high mountain range of the Wahsatch, rising abruptly to the East, and overlooking the southern extension of the great interior basin. An ascent of about 3,000 feet in a distance of three miles, brings us to the outer crest of the range, which extends eastward in an irregular series of undulations to the upper Sevier valley. At several points on the lee side of steep ridges there were still the remains of rapidly wasting snow banks. Notwithstanding the comparative elevation and freshness of vegetation, there was a scant supply of surface water except immediately adjoining large snow banks. The prevalent timber growth was made up of interrupted groves of Aspen poplar, some high ridges in the distance showing a few scattered pines and spruces. Four miles back towards the interior of the range, the country expands into wide grassy slopes, and frequent springs and running streams bordered by snow drifts, give unwonted freshness to the pastoral scenery. Here is located the summer sheep range, and dairy farms of this district, of which the only apparent drawback to their attractive and productive features, is the annoying prevalence of blood-thirsty flies.

The botanical features are very similar to other elevated pastoral districts in the interior West. Senecios and Arnicas serve to give a yellow cast to the open grassy meadows; shades of blue are supplied by thrifty Delphiniums. In the aspen copses there is a dense undergrowth made up mainly of Prunus, Rosa, Symphoricarpus, and Salix. Less conspicuous but more interesting as peculiar to the flora of this district may be noted *Calandrina pygmæa* Gray, *Trifolium eriocephalum* Gray (No. 35), *Oxytrophis campestris* var.? and *Cordylanthus Kingii* Watson (No. 156).

The destructive effects of exclusive sheep grazing on the native forage grasses, was manifest in a disagreeable prevalence of the common yarrow (*Achillea millefolium* L.), wherever the herds had been long stationed. On other hill slopes the entire vegetation was usurped by a bushy perennial umbelliferous plant. *Ligusticum Scopulorum* Gray (No. 82), which alone seemed capable of withstanding the destructive effects of close grazing; possibly its protection is due to some nauseous quality serving to keep the sheep herds at a distance.

On account of the severity of the weather, and the great depth of winter snow, this mountain section is abandoned in the winter for the warmer, though less productive sage-brush lowlands. No attempt has yet been made to establish permanent settlements here for the cultivation of the rich soil, though apparently admirably fitted for the growth of the hardier small grains and root crops.

After spending a few days very pleasantly in the rude homes of these hospitable herders, I returned to Cedar city, by a very direct trail, leading down the steepest part of the mountain slope. On this route I was fortunate in securing good fruiting specimens of *Astragalus megacarpus* Gray (No. 51), hitherto only known from Nuttall's original specimens.

On this same trip my attention was particularly directed to the two species of Rocky mountain balsam, *Abies grandis* Lindl., and *Abies concolor* Engel. ined.; in regard to which so much needless confusion has arisen. I here found the two species growing not far distant from one another, and exhibiting plainly their distinctive characters (as *trees* if not as herbarium specimens). Thus we may note, *Abies grandis* with a more strict habit, narrower leaves, smooth bark (at all sizes) and deep purple cones, more exclusively confined to high elevations. *Per contra; Abies concolor*, less pyramidal in shape, with much broader leaves, rough furrowed bark (in old trees) and apple-green cylindrical cones, found growing at much lower elevations on the mountain slope, and less exclusively confined to moist ground. It is to be hoped that this latter species may soon be introduced into cultivation when its ornamental qualities can be more fully developed. Succeeding my return from the mountain range summer rains set in with unusual frequency and copiousness. Dark thunder clouds hovering about the distant mountains to the east which they illuminated with the

most brilliant electrical discharges, were the sure precursors of floods sweeping down the rocky bed of Cedar creek. The particular location of each storm was plainly indicated by the different colored mud, brought down on the swollen flood, varying from dark brown to dirty yellow or dull red. The stratified deposits thus spread over the bed of the great basin made up the permanent geological record of summer storms in the Wahsatch in 1874.

On the 20th of July I took final leave of this section of southern Utah, carrying with me many pleasant remembrances of the kindness and hospitality received from this much misrepresented Mormon people, who in supplanting the digger Indians by civilized homes of industry and refinement, are deserving of more credit than they have yet received.

The list of plants following will conclude the present paper.

THE INDIAN CEMETERY OF THE GRUTA DAS MUMIAS, SOUTHERN MINAS GERAES, BRAZIL.

BY PROF. CH. FRED. HARTT.

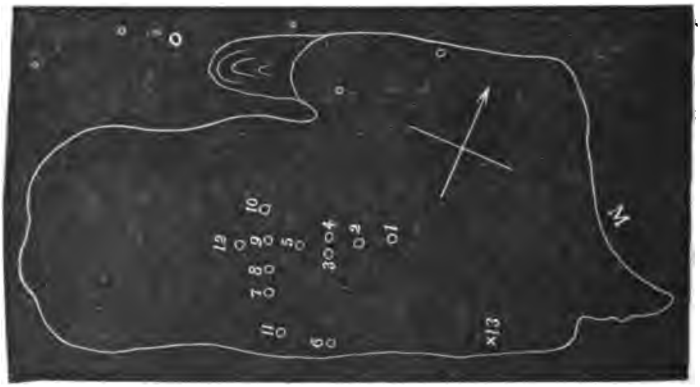
The Fazenda da Fortaleza, also known as Santa Anna, formerly the property of the late Barão de Lage, and probably the finest plantation in Brazil, is situated in the southern part of the province of Minas Geraes at a distance of about seventeen miles to the east of the city of Juiz de Fora.[1] It belongs to-day to the Conselheiro Diogo Velho C. de Albuquergue, a gentlemen celebrated as a politician, and who occupies the important post of President of the União Industria road. The region in which the Fazenda is situated is composed of gneiss, similar to that of the Serra do Mar, and of the vicinity of Rio de Janeiro, and probably of Archæan age.

At a distance of a league, more or less, to the south or southeast of the Fazenda, is a line of high hills of the same gneiss, three of which form prominent heads presenting lofty, almost perpendicular precipices, smooth and rounded and striped vertically with black bands, like the cliffs of the neighborhood of Rio de Ja-

[1] A charming description of this fazenda will be found in Madam Agassiz's "Journey in Brazil."

neiro. The easternmost of these hills, a peak probably not far from three thousand feet in height above the sea, with magnificent, nearly vertical precipices, is called the Fortaleza or the Fortress, and gives its name to the Fazenda. The second hill is lower and less prominent, but towards the northward, in its upper part, it presents a fine rounded, precipitous front, in the solid rock of which are excavated three grottos, one of which, used anciently as a burial place by the Indians, forms the subject of this paper. As this hill has, so far as I have been able to learn, no distinctive ap-

Fig. 74.



Ground plan of Gruta das Mumias showing Interments.

1. Body of child, in basket.
2. Mummied bodies of woman and child.
3. Skeleton wrapped in bast.
4. " " "
5. Remains of child buried in pot.
6. " " " wrapped in hammock.

7, 8, 9, 10. Four pots containing skeletons.

11. Mummied bodies of mother and child buried in the same hammock.
12. Body of little child wrapped in bast and palm straw.
13. Locality where arrow was found.

The compass bears N. magnetic.

pellation, I have taken the liberty to name it after my distinguished friend the proprietor of the Fazenda, calling it the Morro de Diogo Velho. The third mountain is a fine dome about two thousand feet in height, known as the Morro da Babylonia, from whose top a magnificent view of the country to the northward is to be obtained.

In the two last-named hills the beds of gneiss dip to the south-southeastward at an angle of about 40°.

The largest of the caverns, known as the Gruta das Mumias, is situated near the base of a precipice on the northeastern side of

the Morro de Diogo Velho, and at a height of about seven hundred feet above the level of the Fazenda. It consists of an irregular excavation which penetrates the hill in a direction S. 60° W. (mag.) its axis being considerably inclined so that from the mouth to the end of the cave, the floor offers an ascent.

The roof and sides of the cavern form together an arch whose curves are sometimes quite regular. In various parts of the grotto there are in the sides and roof more or less deep, rounded excavations that penetrate the rock in various directions, much resembling potholes, but which are, however, not due to the action of water. On the eastern side of the cavern is one of these excavations which is extending itself in a direction parallel to the axis of the cavern, but has not yet reached the same depth. It is separated from the main hall by a narrow wall of rock which is gradually breaking down and disappearing. Originally, probably, this wall extended farther toward the mouth of the cavern.

The floor of the cave before being disturbed by the work of exploration consisted of a bed of fragments of rock, fallen from the roof and sides, and mingled with earth derived from the decomposition of the gneiss, from the dung of jaguars, bats and other animals, and from the destruction of the enormous clay nests of a large species of bee, which inhabits the cave, building on the roof. When the cavern was discovered the floor was strewn with fragments of these nests, sometimes three feet or more in diameter.

The cavern measures approximately seventy-five feet in length, twenty-five in breadth at the mouth, forty-two feet in greatest breadth and twelve feet more or less in height. The gneiss in which it is excavated consists of distinct, thin, alternating bands of which some are made up principally of a very black mica in small crystals. Others are, for the most part, composed of little grains of silica with but little feldspar, while yet others consist of a mixture of quartz and feldspar rather coarsely crystallized. It is noteworthy that the rock contains no garnets. The beds are inclined to the south-southeastward at an angle of 40°–45°$\pm$, and are full of small, but sharp plications, which, together with the alternation of the white and black bands, give to the rock, as clearly exposed on the sides and roof of the cavern, an exceedingly beautiful appearance. The second cavern is in this respect perhaps even more noteworthy than the first.

Examining the surface of the rock in the interior of the grottos it will be seen that the gneiss is suffering a very rapid decomposition, and is scaling off in thin flakes, which are sometimes so soft as to break up readily between the fingers.

As the gneiss is very compact and had originally but few fractures, and as the decomposition progresses from the outside inwards, the rock of course decomposes concentrically, giving rise to more or less regular, concave surfaces. The surface of the rock inside the cavern is constantly damp, but not sufficiently wet to drip. I suppose that this dampness is for the greater part caused by the soaking through the solid rock of water from above, and that the decomposition is caused mainly by the action of carbonic acid derived from the air.

Large caverns like that just described are rarely encountered in the gneiss of Brazil, but small ones abound and may be seen in the precipices of the gneiss hills of the vicinity of Rio.

It is somewhat difficult to determine just how the caverns of the Morro de Diogo Velho at first originated, but it is very likely that they commenced by the decomposition of an isolated mass in the gneiss, that had a somewhat different mineralogical composition than that of the rest of the rock. Ordinarily, cavities of this kind soon disappear from the surface of a cliff, because of the scaling off of the thick, half decomposed sheet, which falls from time to time, leaving a new surface exposed. It is not at all astonishing that the decomposition should go on irregularly and that the cavity should enlarge itself in some parts more rapidly than in others, giving rise to the pot-hole-like excavations above described. A very slight difference in the hardness of the rock, or in the amount of moisture, would be sufficient to determine the more rapid decomposition of a certain part of the surface, giving rise to a hollow. On the Rio Tapajos the edges of the beds of coal-measure limestone, exposed to the action of the waters of the Igarapé de Bomjardim, during the rainy season, are not dissolved away evenly, but are honeycombed with grottos. Witness also the way in which metals and other substances are honeycombed by acids.

The upper grottos of the Morro de Diogo Velho are like the lower caverns, but smaller. I shall not describe them particularly, because archæologically they do not appear to be of interest,

since they have afforded no human remains. All the caverns, contrary to the opinion of many, are natural excavations, and offer no signs of being, even in part, the work of man.

The lower and larger cavern is perfectly visible from the lowlands to the north, but as it is quite difficult of access, it does not appear to have been visited by civilized persons until, in 1871, Sr. Antunes, the administrator of the plantation, succeeded with much difficulty in reaching it. He, however, saw nothing of the archæological treasures it contained, and their discovery remained to be made by Dr. Manoel Bazilio Furtado, a gentleman, who, much interested in the study of antiquities, has already made explorations of a sepulchral cavern, and of a rock shelter on the head waters of the Rio Itapémerim, an account of which he has promised to furnish me.

As soon as Dr. Bazilio knew of the existence of the caverns of the Morro de Diogo Velho, he visited and examined them, finding human remains in the larger one, thus proving it to be an ancient Indian burial-place. Several other visits were made to the cave, not only by Dr. Bazilio, but also by the Conselheiro Diogo Velho, and by Dr. Rozendo Muniz. About three months ago, Sr. Diogo Velho invited Dr. Ladisláu Netto, the well-known Director of the Museu Nacional of Rio, to visit and examine the locality, and to facilitate the exploration he caused roads to be cut and steps and ladders to be constructed.

Dr. Netto had the kindness to invite me to accompany him, and was so good as to delay the excursion until I could find time to go with him. On the 6th of December, we left Rio in company with Sr. Albuquerque, one of the assistants of the Museum, and M. Glaziou, the Director of the Passeio Publico of Rio, and a man who has probably done more than any one else in the way of actual botanical exploration in Brazil. As my task in this paper is simply to give an account of the scientific results of our explorations, I shall attempt no description of our most interesting journey to the Fazenda of Fortaleza, and I shall be obliged to limit myself to saying that we were overwhelmed with kindnesses and attentions by the hospitable Conselheiro and his friends. Dr. Diogo Velho placed at the disposition of Dr. Netto more than twenty slaves, under the superintendence of Sr. Antunes, and, accompanied by his associates Dr. Machado and Dr. Bazilio, he assisted us personally in the work of exploration.

In the following paper I will give not only the results of my own personal observations, but also the facts relating to the previous explorations, which were furnished me by Dr. Bazilio and Sr. Antunes, and of which my notes were written in the cavern with the greatest care, being afterwards revised by these gentlemen. Dr. Netto has very kindly permitted me to examine the objects sent to the Museu Nacional, so that in this paper I shall be able to give a very complete account of the interments found in it. A detailed description of the human remains themselves I am obliged to defer to another occasion.

As the preliminary excavations in different parts of the cavern offered us no results, we found it necessary to proceed more systematically. We first of all threw out all the large stone and rock masses that encumbered the cavern, amounting to many tons. A line of negroes was then formed across the mouth of the cavern, and the loose earth was examined to a considerable depth from one end of the cave to the other, the work occupying the greater part of two days.

On the first day nothing was found, but very early on the next morning two interments were discovered, one of a child buried in an earthen pot, the other of a young person wrapped up in a hammock, and shortly afterwards there was found the body of a little child enveloped in bast and palm straw. This was the last object discovered.

The following plan (Fig. 74) represents the floor of the cavern and the localities of the various interments, which are numbered as in the following description.

No. 1. Body of a child buried in a well-woven little basket, above which were laid several pieces of bark. Found by Sr. Antunes.

No. 2. Mummied body of a woman with a little child in her arms. These remains were sent to the Museu Nacional, but have not yet been received, so that I cannot describe them.

No. 3. Skeleton wrapped up in bast, but concerning which I could obtain no certain information.

No. 4. Skeleton of a man (?) found wrapped up in bast and afterward in palm straw. It was found sometime before our visit, and had been unwrapped, the bones having, however, been left in the cave. The skull is remarkable for a perforation near the crown, apparently the result of a wound. The remains were to

be sent to the Museum, but not having arrived at time of writing, I have not been able to examine them closely.

No. 5. Bones of a child buried in an earthen vessel, and discovered during our exploration.

The upper part of the *ygaçába* was wanting, together with a large part of the bones, including the skull, and the remaining parts of the vessel were broken, the fragments however remaining *in situ*. The pot was ovoidal in shape, the lower part resembling the tapering end of an egg. It was not at all flattened, and consequently the vessel could be kept upright only by being set in the ground or supported in some way. The material of which it was constructed was clay mixed with somewhat coarse sand. The vessel appears to have been made over a mould; indeed it would have been difficult to build it up in any other way. The inside is slightly rough, showing no signs of having been smoothed by a finishing tool, whose marks are however clearly observable on the outside surface. No signs of paint, of varnish, or of decoration of any kind, were observed on the parts of the vessel preserved.

The burning was incomplete, and for about one-third of the thickness from each surface, the clay of the walls is well reddened, the interior remaining of a grayish color. In the pot were found the following bones belonging to the skeleton of a young person: —The femur, tibia and fibula of one leg, united by the dried ligaments and with parts of the muscles preserved, the knee being flexed, showing that probably the body was buried with the knees doubled up against the breast. There were also the united bones of a fore arm, a scapula, a hand, six dorsal vertebræ, four ribs of the left side united, and in addition six ribs, separated. The rest of the bones were wanting, and I doubt whether they existed in the vessel when it was found by the negroes, for I searched carefully in the earth thrown from the spot, but could find nothing. It seems therefore probable that at some previous time the grave had been disturbed, perhaps by some wild beast. The bones were found mingled with a light earth which appeared to be mainly composed of organic matter, and to be full of the skins of the larvæ of the insects that attacked the body.

In the same earth were also found a number of seeds, which M. Glaziou identified as belonging to a species of *Anona* or custard apple. There were also found numerous fragments of the pinnules

of a species of palm which the same botanist recognized as *Geonoma pinnatifida*. It is probable that the body was wrapped in this palm straw before being deposited in the *ygaçába*. The fragments of the vessel and the bones were destined for the Museu Nacional.

No. 6. Remains of a child from seven to ten years of age, found wrapped in a hammock, and discovered on the second day of our exploration. I assisted in their disinterment, and examined attentively their disposition in the grave.

The body, which is now in part reduced to the state of a mummy, was doubled up with the knees against the breast, and then wound about with the hammock, having exposed the upper part of the head and the feet which last protruded through the hammock. The bundle when found was oval and flattened, and about two feet long. The head was turned toward the left and the body, perhaps owing to the pressure of the superincumbent earth, rested on the left side. The feet were directed towards the mouth of the cavern. The grave was not more than eighteen inches or two feet deep.

The soft parts of the body had for the most part disappeared, but there still remained a part of the scalp with a few hairs and the skin of the trunk which was dry like parchment.

I have not yet been able to examine carefully the hammock, but it appears to be constructed like that which was found wrapped about the woman in the interment No. 11. It is however made of the fibres of a palm, *Astrocaryum tucum*, and not of cotton.

Underneath the hammock adhered what seemed to be fragments of large leaves, that had been laid in the bottom of the grave before the body was deposited. By the side of the hammock there were also found fragments of palm straw, which made me suspect that outside of the hammock was a wrapping of this material. Above the body in the grave, were found a few little sticks which were disarranged in digging. The body was covered simply with earth and stones. The body, still wrapped in the hammock, will be preserved in the Museu Nacional.

Nos. 7, 8, 9, 10. Four *ygaçábas* buried in a line transverse to the grotto. They were extracted before our exploration, and are said to have been sent to the private museum of His Majesty the Emperor, but they have not yet arrived there. The fourth, No. 10, was broken in extraction, and I saw fragments in the hands of Sr. Antunes at the Fazenda. Dr. Bazilio has furnished me with some important notes on each of the four interments.

The *ygaçábas* were all ovoidal in form, without base, and were buried upright. The mouth of each was closed by a round, thick piece of the bark of the *Jequitibá*, set into the orifice. Outside, the urns were covered with a sort of basket-work of the bast of the *Embaúba tinga*, a species of Cecropia, and to this was attached a cord extending across the mouth to serve as a handle, the shape of the *ygaçábas* rendering it necessary to provide means of this kind for their conduction. It is worthy of note that all the urns are small and contain only the bones of children.

Over the mouth of No. 8 was found a small basket a little more than eight inches in diameter and made of *cipó tinga* a kind of lliana, which had been split, carefully prepared and woven in an open manner, the basket being furnished with a cord across the mouth, to serve as a handle. It contained a number of little bundles of palm straw, similar to those that form the outside covering of the body in No. 12. The basket was crushed flat by the weight of the earth and stones. By the side of the same *ygaçába* was found interred a bundle of five sticks, bound near each end by a bit of *cipó*. These sticks were of about the thickness of a finger and four were about three feet in length, the fifth was somewhat shorter. They were all sharp at one extremity and blunt and polished at the other. My friend Dr. Muniz Barretto, who was present when the pot was found, tells me that it contained the skeleton of a child wrapped up in bast and palm straw, forming a bundle which was afterward tied up with a cord of the palm fibre.

By the side of No. 9, and in part bent over the mouth of the pot, was found a "bornal de caça" or a sort of small haversack, woven in an open manner of palm fibre thread, and furnished with a long cord by which it might be carried like a game bag. According to the description of Dr. Bazilio this "bornal" was of exactly the same shape as the sacks used at present, not only by the Botocudos but also by many other Indian tribes of Brazil. The sack was full of little bundles of palm straw, similar to those found in the basket accompanying No. 8.

The *ygaçába*, No. 10, broken in extraction, contained the bones of a child of about twelve years of age and which had already finished its first dentition. The vessel of which Sr. Antunes showed me fragments, was of the form of an egg truncated at the larger end. The mouth was large and entirely without lip. The

interior of the vessel showed the casts of striæ on the mould. The exterior surface was moderately well worked down, showing, however, long, hard marks of the finishing tool. There were no signs either of ornament or of glazing.

The four *ygaçábas* were separated one from the other by little sticks, which circumstance makes me suspect that they were all deposited together.

On the surface of the ground near the pots, but in a position which I am unable to indicate on the plan, was found the body of a child probably wrapped up in bast.

No. 11. Mummied bodies of a mother and new-born child, wrapped in the same hammock. These most interesting specimens are preserved in the Museu Nacional where I have had an opportunity of examining them. The body of the woman is a natural mummy, simply preserved in a half decomposed and dry state. The skin remains on nearly the whole body, and, so perfect is the state of preservation, that the lower lip remains, and the feet are simply shrivelled up. The body reclines somewhat on the left side. The head is turned to the left. The left hand was placed on the breast and the right was held just above the abdomen. The legs, partially drawn up, are bent over to the left The body bears no ornament.

By the left side of the corpse was found a little bundle containing the dried-up, natural mummy of a new-born babe, much doubled up and wrinkled and but little discolored. The skin is well preserved. The left arm bears a sort of band of woven string, and on one leg is a string of beads made of rather wide sections of a hollow bone strung on a coarse thread, a touching evidence of tenderness. The body was wrapped up in bast, and tied outside with a coarse string which passed through the fingers of the right hand of the woman, who in death was thus closely united to her offspring. It is very probable that the woman died in childbirth, but this is a question in medical jurisprudence which I am not competent to decide. Both mother and child were buried in the same hammock, which is in a fair state of preservation and accompanies the body in the museum, but, as it has been removed from the mummies, it is not possible to determine the manner in which it was wound about them. The hammock consists of rather coarse cotton thread, and is constructed like that in which the body of the young person, No. 6, is en-

wrapped. It consists of threads parallel to one another and considerably spaced, united together at intervals of a foot or more by transverse threads. At the two extremities of the hammock, the threads appear to be simply gathered together for the attachment of a stout cord for suspension.

In the manner of weaving, or rather in the arrangement of the threads, the hammocks of the cavern of the Morro de Diogo Velho bear a close resemblance to that represented in one of Lery's woodcuts,[2] but the form is different. Lery says that the Brazilian Indians made their *inis* of cotton thread, sometimes like a net, sometimes woven into a close cloth. Both Lery and Stade call the hammock *ini* or *inni*, a word which I have sought in vain in Tupí dictionaries, and which does not occur to-day in Lingoa geral.

On the Amazonas the name for hammock is *kyçána* (*kyçába*, old Tupí), a word which seems to have been derived from ker dormir (to sleep) and the termination *çábá* or *çána*, which indicates the instrument with which anything is done. In the language of the Mundurucus I have found *ŭlu* and in that of the Maués *yly* meaning hammock, both of which forms may well have been derived from the same source as *ini*, as the three languages above enumerated belong to the same family.

Underneath the bundle formed by the two bodies were laid side by side a number of broad strips of coarse bark.

Over the bodies was deposited upside down a basket, well made and full of little bundles of palm straw, each with a knot. Over this were laid side by side strips of coarse bark, like those underneath the body, the whole being covered with earth.

In the same grave was found a "bornal" similar to that already described, but in a bad state of preservation.

No. 12. Bundle containing the remains of a little child, found buried at a slight depth and extracted in my presence. The body was well wrapped in the first place in strips of bast forming a little bundle scarcely eighteen inches long, a foot and a half broad and about four inches high. This package was then loosely covered on the outside with palm straw, which was tied up in a number of little bundles like those found in the baskets, and the "bornal" already described. The body was deposited immediately upon a flat stone, and over it were placed, side by side, four flat pieces of bark, about two feet long and two inches wide, forming a sort of

[1] Lery, Historia Navigationis in Brasiliam, edition 1586, p. 252.

protecting covering. The bast, palm straw, and bark are all well preserved but the package has not been opened.

I examined the cavern carefully everywhere for objects of stone, fireplaces, etc., but found no sign that it had ever been either a dwelling or that it was a place much resorted to. Sr. Antunes found on the floor of the cavern a fire brand and a long split stick which he thought might have been used to collect water, but both these objects may be very recent. In the spot marked 13 a sharpened stick was found buried. I have not seen it, but Dr. Bazilio thought it to be an arrow.

The observations made in the Gruta das Mumias show that the cavern is a natural excavation which has served as a cemetery to savage Indians. So far as the mode of burial and the preservation of the bodies are concerned it offers nothing very novel, but as an archæological locality carefully explored it is of much importance.

The Gruta das Mumias is not the only cave in Brazil in which Indian interments have been found. Dr. Bazilio found a large number of skeletons in a cave near the head waters of the Itapémerim. A similar excavation is reported to exist near Macahé, and yet another containing mummied bodies and urns in the Serra dos Dois Irmãos, near the head waters of the Rio Parahyba do Norte. My friend, Sr. D. S. Ferreira Penna, discovered another in Brazilian Guyana, in which was found the portrait urn I described and figured some time ago in the AMERICAN NATURALIST. Every one will remember the cave of the Atures on the Orinoco visited by Humboldt.

The burial of the dead in the hammock has been described over and over again by writers on the Brazilian Indians, and the same custom is still in force to-day among many tribes, but I do not remember having met with a description of the mode of wrapping the body in strips of bast and in palm straw.

Urn burial was practised by many ancient Brazilian tribes, and is still in use to-day in many parts of the country.

Two Tupí names are applied to the burial urn in Brazil, *ygaçába* and *camutí* or *camutím*. The former simply means a vessel to hold water, the latter a pot of any kind. It is a great mistake to suppose that either name belongs exclusively to the burial vase.

Ordinarily the vessel is not made on purpose for the body, but one of the larger earthen pots for water, or for brewing *cauim* is

used. It is safe to say that when the corpse is to be buried immediately the vase is not made on purpose. It takes time to make and ornament an earthen vessel, and true burial vases in Brazil will usually be found to contain only the cleaned bones of the dead. Those of Marajó are often made with the greatest care and most elaborately ornamented. I have already called attention to the facts that they are often true *gesichtsurnem*, wonderfully resembling those of the old world, about which so much has of late years been written by German archæologists.

As to the antiquity of the interments in the Gruta das Mumias, nothing whatever can be at present determined. At first sight, the state of preservation in some cases of hair of the skin of cartilages and dried muscles, of hammocks and bags, etc., would appear to indicate that the bodies were buried at an extremely recent date, but it is well known that, for very many years, no savage Indians have existed in the vicinity.

In the decomposition of a human body in a dry place, the soft parts disappear quickly, but the skin, the cartilages and other parts, may dry up and be preserved indefinitely. This loose material in which the bodies were buried was extremely dry, so dry that, though our explorations were made in the wet season and even during heavy rains, the negroes in working raised a thick cloud of dust, that at one time drove us from the cave. This dry material, probably containing much saltpetre, is particularly adapted for the preservation of organic substances. The human remains of the cave may be many hundreds of years old.

In the present state of our knowledge of Brazilian archæology, it is impossible to determine the tribe to which the cemetery belonged. We are ignorant of the epoch of the interment and of the history of the different tribes, that in turn have occupied the locality. Indeed, the little information that we possess of the aborigines last known to have existed in this part of southern Minas is meagre in the extreme.

THE MODE OF GROWTH OF THE RADIATES.

BY A. S. PACKARD, JR.

III. THE ACTINOZOA.

The sea anemones and coral polypes are more highly developed than the Hydroids, since the mouth opens into a double digestive cavity, which is supported for its whole length by the six primary curtains or septa. The second and lower half of the cavity enlarges greatly, and communicates with the general cavity of the body, the upper portion being entire, tubular, and forming a sort of throat opening into the proper digestive cavity. In the Hydroids, the digestive cavity, it may be remembered, is simply hollowed out of the body cavity and is a more primitive affair than that of the Actiniæ.

While in the Hydroids also the ovaries hang outside the body cavity, in the true polypes they are attached to the septa or walls of the radiating chambers, so that the eggs, when ripe, drop down into the body cavity, whence they pass out through the mouth, or, as observed by Lacaze-Duthiers, in the coral polypes through the tentacles. The chambers between the septa correspond to the water canals, or chymiferous tubes of the Hydroids.

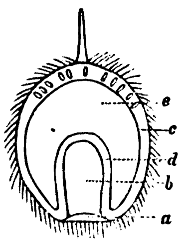
In the coral polypes the coral is secreted in the chambers, so that there are soft partitions alternating with the limestone ones. The tentacles which surround the mouth vary greatly in number. They are hollow, each communicating with a chamber.

The polypes are divided into (1), the Actinoids (Zoantharia) which either secrete no limestone, as in the sea anemones, or form a coral stock, as in the coral polypes, and have an indefinite number of tentacles, and (2), the Halcyonoids, in which the tentacles are eight in number. Such are the sea fans (Gorgonia) and Halcyonium, which does not secrete a coral stock.

Development. The life history of a polype is soon told. Naturalists are indebted to the magnificent memoirs of Lacaze-Duthiers for a full biography of not only several genera of sea anemones (*Actinia mesembryanthemum*, Bunodes and Sagartia) but also of the Gorgonia, Halcyonium, red coral, and the Astræoides, a Mediterranean form allied to Astræa.

The young sea anemone develops without any metamorphosis, directly into the adult condition. Lacaze-Duthiers could not determine by actual sight how fecundation of the egg takes place, or whether the egg passes through a morula stage or not, though he infers, with every reason, that this stage, *i. e.*, the segmentation of the egg contents, takes place in the ovary. The ovaries and spermaries are in the Actiniæ situated in the same individual; the eggs are oval, while the spermatic cells are of the usual tailed form. The fecundated egg in the state in which it was first seen by Lacaze-Duthiers was oval, and surrounded by a dense coat of transparent conical spinules. He was soon able to detect the presence of the two primitive germinal layers, the ectoderm and endoderm. Fig. 75 (from Metschnikoff) illustrates the relation of the embryonal layers in the larva of another polype which he calls "kaliphobenartige Polypen larve;" *a*, primitive opening into the gastro-vascular cavity; *b*, *c*, ectoderm; *d*, entoderm; *e*, body cavity), showing that the walls of the digestive cavity are formed by the entoderm; and Metschnikoff's figure shows that the embryo polype has a greater resemblance to the embryo starfish of the same age than the acalephs.

Fig. 75.



Ciliated larva of a Polype.

Two lobes next appear within the body, these subdivide into four, eight and finally twelve primitive lobes. This stage is represented by the corresponding stage of the coral (Fig. 77, B). Not until after the twelve primitive lobes are fully formed do the tentacles begin to make their appearance. When the first twelve tentacles have grown out, twenty-four more arise, and so on, until with its increasing size the actinia is provided with the full number peculiar to each species. The preceding remarks apply to *Actinia mesembryanthemum*, but Lacaze-Duthiers observed the same changes in two species of Sagartia and in *Bunodes gemmacea*.

Turning now to the stony corals we will give more fully the sequence of events in the life of a coral builder of the Mediterranean, the *Astræoïdes calycularis*, so faithfully narrated by Lacaze-Duthiers. Fig. 76 taken from Tenney's "Manual of Zoology" illustrates this coral in various stages of expansion.

He studied this coral on the coast of Algiers, and found that reproduction took place between the end of May and July, the

young developing most actively at the end of June. Unlike Actinia, which is always hermaphrodite, this coral is rarely so, but the polypes of different branches belong to different sexes.

As in the other polypes, including Actinia, the eggs and spermatic particles rupture the walls of their respective glands situated in the fleshy partitions. As in Actinia, Lacaze-Duthiers thinks the fecundation of the egg occurs before it leaves the ovary, when also the segmentation of the yolk must take place. Unlike the embryo Actinia, the ciliated young of the coral, after remaining in the digestive cavity for three or four weeks, make their way out into the world through the tentacles. "Many times," says Lacaze-Duthiers "have I seen the end of the tentacle break and let out

Fig. 76.

Coral polype (Astræoides calycularis) expanded.

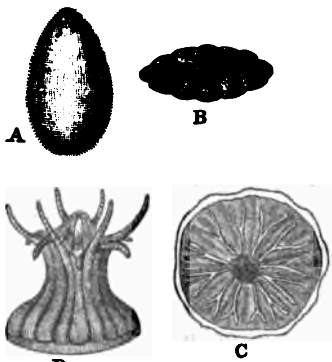
the embryo." The appearance of the embryo, when first observed, was like that in Fig. 77, A, an oval, ciliated body with a small mouth and a digestive cavity. This may be called the gastrula, adopting Hæckel's phraseology.

The gastrula changes into an actinoid polype in from thirty to forty days in confinement, after exclusion from the parent, but in nature in a less time, and it probably does not usually leave the mother until ready to fix itself to the bottom.

Before the embryo becomes fixed and the tentacles arise, the lime destined to form the partitions begins to be deposited in the endoderm. Fig. 77, C, shows the twelve rudimentary septa. These after the young actinia, or "actinula" (Allman), has become stationary, finally enlarge and become joined to the external

walls of the coral now in course of formation (Fig. 77 C, *c*) forming a groundwork or pedestal on which the actinula rests. D represents the young polype resting on the limestone pedestal.

Fig. 77.



Development of a coral polype, Astræoides calycularis. After L. Duthiers.

In the experience of Lacaze-Duthiers it happened that the embryo polype which had been swimming about in his jars for about a month, suddenly, within the space of three or four hours after a hot sirocco had been blowing for three days, assumed the form of small disks (Fig. 77, B), divided as in the Actinia into twelve small folds forming the bases of the partitions within.

Fig. 78.

Halcampa albida.

The tentacles next arise, being the elongation of the chambers between the partitions, six larger and elevated, six smaller and depressed (Fig. 77, D). The definitive form of the coral polype is now assumed, and in the Astræoides it becomes a compound polypary.

The singular floating young Edwardsia, originally described under the name *Arachnactis*, has been found by Mr. A. Agassiz to be the early swimming stage of Edwardsia, a worm-like Actinian, which, like *Halcampa albida* (Fig. 78[1]), lives in the sand or mud, unattached to any fixed object.

Kowalevsky has lately found that the Cerianthus, a gigantic Actinia which lives in a tube in the mud at great depths, has a free swimming early stage like Edwardsia.

The following is a summary of the changes undergone by the polypes so far as known:—

1. Egg fertilized by true spermatozoa.
2? Morula.

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[1] This figure was kindly loaned by Professor S. F. Baird, U. S. Commissioner of Fish and Fisheries.

3. Planula (Gastrula).
4. Actinula, with twelve primitive tentacles.
5. Adult actinia or polype.

LITERATURE.

Lacaze-Duthiers. Développment des Coralliaires (Lacaze-Duthiers' Archives de Zoologie Experimentale, etc. 1872, 1873).

IV. THE CTENOPHORÆ.

These beautiful animals derive their name Ctenophoræ, or "comb-bearers," from the vertical rows of comb-like paddles, situated on horizontal bands of muscles, which serve as locomotive organs, the body not contracting and dilating as in the true jelly fishes. In their organization they are much more complicated than any animals of which we have yet spoken, as it has been shown by the two Agassizs that they have a true digestive cavity, passing through the body cavity, with a posterior outlet, and originating in the same manner as in the Echinoderms. From this alimentary canal are sent off chymiferous tubes which "correspond in every respect with the water tubes of the Echinoderms" (A. Agassiz). The rows of paddles are intimately connected with the chymiferous tubes, so that the movements of the body are in direct relation with the act of breathing. Moreover these animals, while in the disposition of the organs following the radiate plan of structure, are also more truly bilateral than any of the lower classes of radiates. The sexes are united in the same individual; the ovaries in Idyia are on one side of the main chymiferous tube, and the spermaries on the other, both being brilliantly colored.

Referring the reader for farther details to Mr. A. Agassiz's "Sea Side Studies," where these animals are described and illustrated with sufficient detail for the general reader, we will now turn to their mode of growth, under the guidance of the same author, whose recent richly illustrated memoir, with others by Kowalevsky and Fol leaves but few gaps to be filled by future observers.

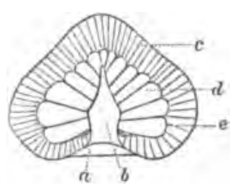
Development. Agassiz states that the Ctenophoræ are readily kept in confinement, and from twelve to twenty-four hours after they are captured lay their eggs, either singly or in strings, or, as in Idyia, in a thick slimy mass. The Ctenophoræ of our eastern coast spawn from late in July through August and September. "The young brood developed during the fall, comes to

the surface again the following spring as nearly full-grown Ctenophoræ, to lay their eggs late in the summer." Fortunately the eggs are so transparent that in some forms (Pleurobrachia and Bolina) the embryology can be studied, not only in the egg but also through nearly all the earlier stages of the larva.

Selecting Pleurobrachia as an example of the mode of growth, we find that as in Idyia the egg consists of two layers, *i. e.* an inner yolk mass and an outer, thin, finely granular layer surrounded by a transparent envelope. The inner mass acts merely as a nutritive mass, while the outer is the true embryonic layer, which builds up the body at the expense of the central nutritive mass. No nucleus nor nucleolus has been observed by Agassiz in the eggs of any Ctenophoræ, after they are once laid, until late in the stage of segmentation. The egg divides into four and again eight spheres of segmentation, each of which has, like the egg, originally an outer and inner mass. In a second stage of segmentation small cells arise which surround the original eight large cells. From these small cells the external organs are destined to arise, while the larger cells form a yolk mass out of which the internal organs arise.

The embryonal layer is next formed, then the outer wall by "the gradual encroachment of the actinal cells over the whole of the yolk mass." Finally, the mouth (actinostome) of the germ is formed, and afterwards the digestive cavity, which results from an invagination of the outer embryonic layer (ectoderm). Fig. 79 (after Metschnikoff) represents the larva of a Cydippe; *a*, primitive opening; *b*, gastro vascular cavity; *c*, ectoderm; *d*, endoderm; *e*, interspace corresponding to the body cavity of the larva of the polype. The development of the chymiferous tubes is succeeded by that of the locomotive flappers, eight or nine pairs in each row appearing before the young leave the egg, and of the fringed tentacle, which attains a great length after the young is hatched.

Fig. 79.



Gastrula of Cydippe.

Finally the definitive form of the Pleurobrachia is attained before it leaves the egg, as seen in Fig. 80 (*t*, tentacles; *e*, eye-speck; *c*, *c*, rows of locomotive flappers; *d*, digestive cavity; greatly magnified after A. Agassiz).

Fig. 81 shows the young Pleurobrachia swimming about in the egg just before hatching, and in Fig. 82 (after A. Agassiz), we see the young after hatching (magnified) with nearly the same form as the adult; *f* indicates the funnel leading to the anal opening, *l*, the lateral tubes, and *c c c′ c′* the rows of locomotive flappers. The remaining changes are slight, and there is not even a slight metamorphosis, the body simply becoming spherical and the tentacles increasing enormously in length. In Bolina and its allies, as A. Agassiz states, "the morphological changes are very great, and it would indeed puzzle the most accurate systematist to recognize in the early stages of some of the Mnemidæ the young of well known genera. We cannot say that there is a metamorphosis in the ordinary sense of the word, as supposed by Gegenbaur, but there certainly are remark-

Fig. 80.

Young Pleurobrachia still in the Egg.

Fig. 81.

Young Pleurobrachia swimming in egg ready to hatch.

Fig. 82.

The same after hatching.

able changes, such as the almost total suppression of the tentacular apparatus, the development of auricles, of lobes, with their complicated winding chymiferous tubes, which alter radically the appearance of the Ctenophoræ at successive periods of growth, and present between the younger and the older stages differences usually considered as of great systematic value."

The summary of stages is very brief, the Ctenophore passing through three phases:—

1. Egg stage.
2. Morula state.
3. Adult form, assumed before hatching.

LITERATURE.

E. C. and *A. Agassiz.* Seaside Studies. 1863.

A. Agassiz. Catalogue of North American Acalephæ. 1865.

Kowalevsky. Entwickelungsgeschichte der Rippenquallen. (Mémoires Acad., St. Petersbourg, x. No 4.)

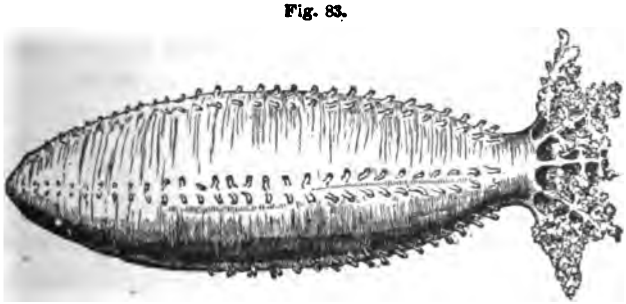
Fol. Ein Beitrag zur Anatomie und Entwickelung einiger Rippenquallen. (Siebold and Kölliker's Zeitschrift, 1869.)

A. Agassiz. Embryology of the Ctenophoræ. (Memoirs Amer. Acad. Arts and Sciences. x, No. 3, 1874.)

V. THE ECHINODERMS.

The Echinoderms (starfishes, sea urchins and sea cucumbers) are far more complicated than the Cœlenterates, having a true alimentary canal passing through the general cavity of the body. In them for the first time among the Radiates appears a well developed nervous system. Not only do the young exhibit a bilateral symmetry, but in the higher forms, as the spantangoid sea urchins,

Fig. 83.



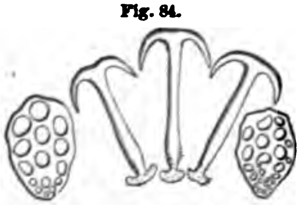
Pentacta frondosa (From Tenney's Zoology.)

this is quite well marked; and there is a dorsal and ventral side. Still, in the generality of the forms, the radiated plan of structure is remarkably adhered to, the body as distinctly made up of sphæromeres, or wedge-shaped sections of the body, as the worms are of segments (arthromeres). In this and other respects, as well as the form of the larvæ, there is a remarkable parallelism between the worms and echinoderms.

We will briefly review some of the anatomical features of the Echinoderms, in order to understand their complicated mode of growth.

The stomach and intestinal canal either pass straight or in a spiral course through the body, as in the sea urchins (Fig 103) and Holothurians (Fig. 83), and open out at the opposite end; or, as in the Antedon (Comatula), the anal opening is situated near the mouth, while in the Ophiurans (Fig. 85) and Luidia and Astropecten, low starfishes, the undigested food is rejected from the mouth. In the starfishes and Holothurians, the alimentary canal opens into five voluminous cæcal appendages. These are wanting in the Ophiurans, and there are but two in Astropecten. They are in connection with the complicated water tubes, which consist of a canal surrounding the mouth and sending branches out into the rays of the starfishes in communication with the locomotive organs or suckers, called ambulacra. The water fills the tubes through a duct leading from the sieve-like plate, situated in the dorsal (abactinal) portion of the body. Near this duct is the pulsating tube, the so-called heart.

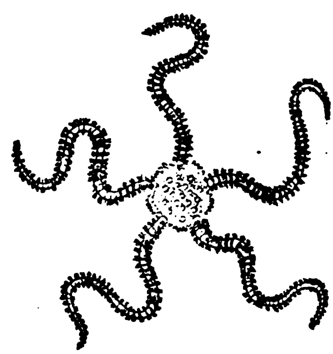
Fig. 84.



Hooks and Plates of Synapta.

The Echinoderms are further distinguished by the body walls secreting calcareous plates, often forming a solid limestone shell, as in the sea urchins; or the plates are smaller and movable as in the starfishes, or as in the sea cucumbers they are microscopic, buried in the skin; sometimes, as in the Synapta forming anchor-like hooks and small plates (Fig. 84).

Fig. 85.



Sand star (Ophiopholis aculeata).

The sexes are as a rule distinct. In *Ophiura squamata* and Synapta they are united in the same individual. The ovaries and testes are gland-like masses situated at the base of the arms in the starfishes, or between the ambulacra in the sea urchins. The ovaries are red or yellow, the male glands

whitish. In the Ophiurans the eggs and spermatozoa pass out of the body through little holes between the plates on the under side of the body. In those starfishes in which the alimentary canal is a blind sac, the eggs are emptied into the body cavity; but how they pass out is unknown. In some starfishes they escape through certain (interradial) plates on the back. In the Echinoids they make their exit from between the ambulacra. In the Holothurians, however, there is a duct leading from the generative gland opening out near the mouth, between the tentacles. The eggs are usually round, and minute; the spermatozoa of the usual tailed form. Fertilization takes place in the water.

Remembering that there are five well-marked divisions of Echinoderms, *i.e.*, *Crinoidea*, *Ophiuroidea*, *Asteroidea*, *Echinoidea*, and *Holothuroidea*, we will now review some of the main points in the mode of development of the respective orders.

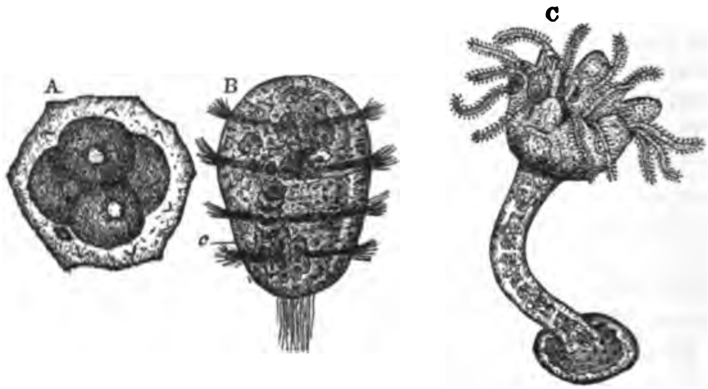
Development of the Crinoids. While we know nothing of the mode of development of the true Pentacrinus and Rhizocrinus, the lineal descendants of the Crinoids of the earlier geological ages, we have quite full information regarding the life-history of the Antedon, which is for a part of its life stalked, and is in fact a true crinoid.

The following account is taken (sometimes word for word) from Professor Wyville Thompson's researches on the *Antedon rosaceus* of the British coast. The ovaries open externally on the pinnules of the arms, while there is no special opening for the spermatic particles, and Prof. Thompson thinks they are "discharged by the thinning away and dehiscence of the integument." The ripe eggs hang for three or four days from the opening like a bunch of grapes, and it is during this period that they are impregnated. The egg then undergoes total segmentation. Fig. 86, A, represents the egg with four nucleated cells, an early phase of the mulberry or morula stage. After the segmentation of the yolk is finished, the cells become fused together into a mass of indifferent protoplasm, with no trace of organization, but with a few fat cells in the centre. This protoplasmic layer becomes converted into an oval embryo, whose surface is uniformly ciliated. The mouth is formed, with the large cilia around it, before the embryo leaves the egg. When hatched, the larva is long, oval, and girded with four zones of cilia, with a tuft of cilia at the end, a mouth and anal opening, and is about ·8 millimetre in length. The body cavity is formed by an

inversion of the primitive sarcode layer which seems to correspond to the ectoderm.

Within a few hours or sometimes days, there are indications of the calcareous areolated plates forming the cup of the future crinoid. Soon others appear forming a sort of trellis work of plates and gradually build up the stalk, and lastly appears the cribriform basal plate. Fig. 86, B, *c*, represents the young crinoid in the middle of the larva, whose body is somewhat compressed under the covering glass. Next appears a hollow sheath of parallel calcareous rods, bound, as it were, in the centre by the calcareous plates. This stalk (B, *c*) arises on one side of the digestive

Fig. 86.



Development of a Crinoid (Antedon).

cavity of the larva, and there is no connection between the body cavity of the larva and that of the embryo crinoid.

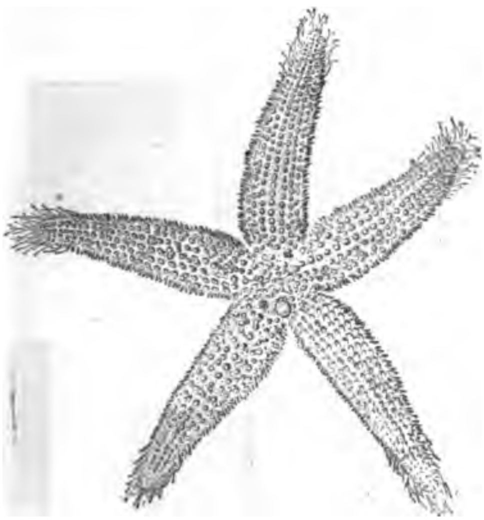
Two or three days after the appearance of the plates of the crinoid, the larva begins to change its form. The mouth and digestive cavity disappear, not being converted into those of the crinoid. The larva sinks to the bottom resting on a seaweed or stone to which it finally adheres. The Pentacrinus is embedded in the former larval body (the cilia having disappeared), now constituting a layer of sarcode conforming to the outline of the Antedon.

Meanwhile the cup of the crinoid has been forming. It then assumes the shape of an open bell; the mouth is formed, and five lobes arise from the edges of the calyx. Afterwards five or more, usually fifteen tentacles, grow out, and the young Antedon appears

as in Fig. 86, C (after Thompson). The walls of the stomach then separate from the body-wall. The animal now represents the primary stage of the crinoids, that which is the permanent stage in the Pentacrinus and its fossil allies. The Antedon, however, in after life separates from the stalk and moves about freely.

Development of the Starfish. We will select as a type of the mode of development of the starfishes, that of the common five finger, Asterias (Fig. 87), as worked out with great thoroughness

Fig. 87.



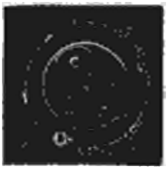
Asterias.

by Mr. A. Agassiz, and given in the "Seaside Studies." The accompanying illustrations are taken from this work and the original memoir, through the kindness of the author, whose description is here freely used.

Fig. 88 shows the transparent spherical egg, enclosing the germinative vesicle and dot, and Figs. 89, 90, illustrate the segmentation of the yolk into two and eight and more cells, enclosing a central cavity. After this the embryo hatches and swims about as a transparent sphere (Fig. 91). A depression (Fig. 92, *ma*) then begins to appear, the body elongates, and this depression forms an inversion of the outer wall of the body (ectoderm), constituting the body cavity (*d*, Fig. 93, *a*), being the provisional mouth-

opening, afterwards becoming the anal opening; at this time, however, serving both for taking in and rejecting the food). From the upper extremity of the digestive cavity next project two lobes (*w*, *w′*, Fig. 94, *m*, mouth). These separate from their attachment and form two distinct hollow cavities (*w*, *w′*, Fig. 95, *a*, *d*, *c*, digestive system; *v*, vibratile chord; *m*, mouth). Here begins the true history of the young starfish, for these two cavities will develop into two water-tubes, on one of which the back of the starfish, that is, its upper surface, covered with spines, will be developed, while on the other, the lower surface, with the suckers and

Fig. 88.



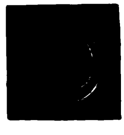
Egg of Starfish.

Fig. 89.

Fig. 90.

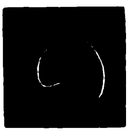
Segmentation of yolk.

Fig. 91.



a
Free swimming germ.

Fig. 92.



ma
The same, older.

Fig. 93.

d
a
Gastrula.

Fig. 94.
m

Mouth of Gastrula.

Fig. 95.

Larva.

tentacles, will arise. At a very early stage one of these water tubes (*w′* Fig. 96) connects with a smaller tube opening outwards, which is hereafter to be the madreporic body (*b*, Fig. 96). Almost until the end of its growth, these two surfaces, as we shall see, remain separate and form an open angle with one another; it is only toward the end of their development that they unite, enclosing between them the internal organs, which have been built up in the meanwhile.

"At about the same time with the development of these two pouches, so important in the animal's future history, the digestive cavity becomes slightly curved, bending its upper end sideways

till it meets the outer wall, and forms a junction with it (*m*, Fig. 97; *o*, digestive cavity). At this point, where the juncture takes place, an aperture is presently formed, which is the true mouth. The digestive sac, which has thus far served as the only internal cavity, now contracts at certain distances, and forms three distinct, though connected cavities as in Fig. 96, viz., the œsophagus leading directly from the mouth (*m*) to the second cavity or stomach (*d*), which opens in its turn into the third cavity, the alimentary canal. Meanwhile the water-tubes have been elongating till they now surround the digestive cavity, extending on the other side of it beyond the mouth, where they unite, thus forming a

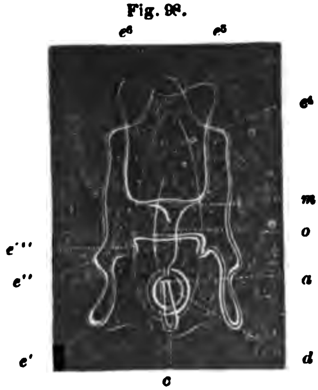
Fig. 96.

Profile view of Larva.

Fig. 97.

Larva.

Fig. 98.



Larva with arms developing.

Y-shaped tube, narrowing at one extremity, and dividing into two branches toward the other end, Fig. 98.[2]

"On the surface where the mouth is formed, and very near it on either side, two small ones arise, as *v* in Fig. 95; these are cords consisting entirely of vibratile cilia. They are the locomotive organs of the young embryo, and they gradually extend until they respectively enclose nearly the whole of the upper and lower half of the body, forming two large shields or plastrons (Figs. 98, 99). The corners of these shields project, slightly at first (Fig. 98), but elongating more and more until a number of arms are formed, stretching in various directions (Figs. 99, 100)[3] and, by their con-

---

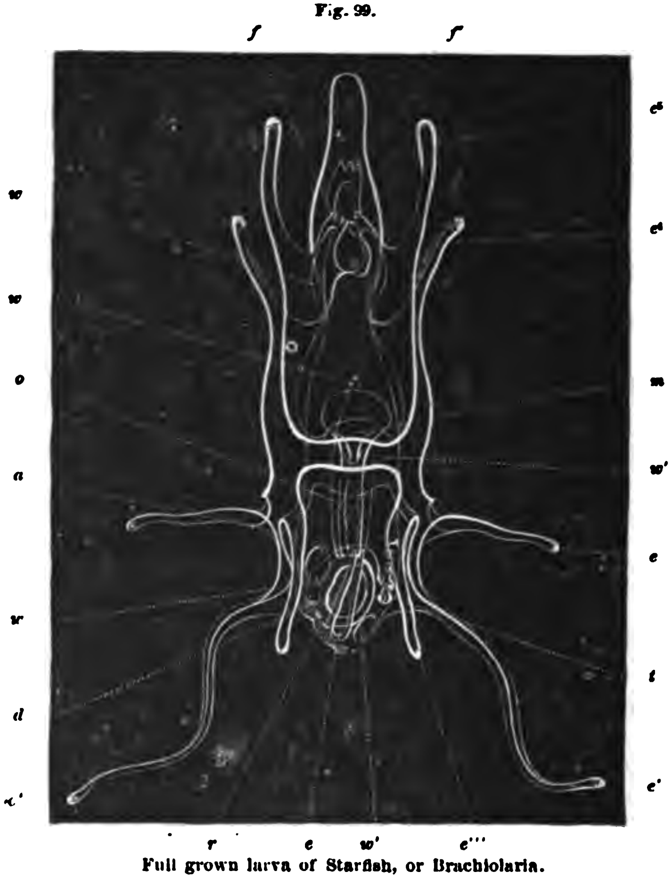
[2] Fig. 98 *a*, anus; *c*, intestine; *e' e'' e''' e⁴ e⁵ e⁶*, arms; *o*, œsophagus.

[3] Figs. 99, 100, side view of 99. Adult larva, so-called Brachiolaria, lettering the same in all the figures; *t*, tentacles of young starfish; *f f*, brachiolar appendages; *r*, back of young starfish. Fig. 101, *t'*, odd tentacle.

stant upward and downward play, moving the embryo about in the water" (A. Agassiz).

Having reached the Brachiolaria stage, the body of the future starfish begins to develop. On one of the water-tubes (w') the tentacles of the future starfish arise as a series of lobes (t); while

Fig. 99.



Full grown larva of Starfish, or Brachiolaria.

on the opposite water-tube (w), arise a number of little calcareous rods, which afterwards form a continuous net-work; r indicates the back of the young starfish. The larva now shrinks and drops to the bottom and attaches itself there by means of the short arms (ff' Fig. 99). The starfish now absorbs the larva, and

appears of an oval form with a crenulated edge, and soon reaches a stage indicated by Fig. 101. (Fig. 102, the same seen in profile).

In this stage it remains probably two or three years before the arms lengthen and the adult form is assumed.

Fig. 100.

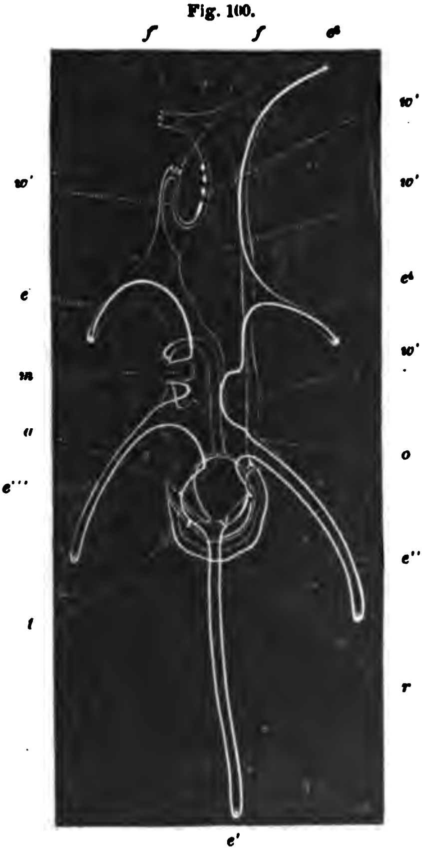


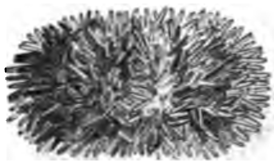
Fig. 99 seen in profile.

The development of the Ophiurans is much like that of the starfish, with some characters of the embryo sea urchin. The larva of the sand star (Ophiura) is called a Pluteus, and is remarkable for the great length of two of the arms.

Development of the Echinoids. The researches of Mr. A. Agassiz, who has given us a very complete history of the common sea urchin of the northern shores of the United States in his "Revision of the Echini," will be our guide in these studies. The earlier stages of development were obtained by artificial fecundation of the egg during February. The early embryonic stages are much as described in the starfishes, the process requiring but a few hours. The embryo when hatched is like that of the starfish at the same period (Fig. 91) and then it passes into the gastrula stage (Fig. 104, lettering the same in all the figures as in those of the starfish) the digestive cavity being formed by an inversion of the ectoderm. "The embryo, in escaping from the egg, resembles a starfish embryo, and it would greatly puzzle any one to perceive any difference between them. The formation of the stomach, of the œsophagus, of the intestine, and of the water tubes takes

place in exactly the same manner as in the starfish, the time only at which these different organs are differentiated not being the same. In figure 105 we see the beginning at w and w' of the water tubes arising as pouches sent off from the digestive cavity, and T-shaped rudiments of the limestone rods (r), so characteristic of the larva of the sea urchin are now visible."

Fig. 103.



Common Sea Urchin (Echinus).

Fig. 106 represents the larva well advanced towards the pluteus stage. It is now in the tenth day after fecundation.[4] The arms are now well marked, and the "vibratile epaulettes" appear. When the larva is twenty-three days

Fig. 101.

Young Starfish seen from the back.

Fig. 102.

Young Starfish seen in profile.

old, the rudiments of the five tentacles of the sea urchin appear, the first one on the left water tube. The arms have increased in length, until in the full-grown larva, now called the pluteus (Figs. 107, 108, the same seen sidewise) the arms with the calcareous rods supporting them are of great length, opening and shutting like the rods of an umbrella; while the sea urchin growing within has concealed the shape of the digestive cavity of the larva, and the spines are so large as to conceal the tentacles.

[4] Fig. 106, o-o^v arms; v-v', vibratile chord, w w^4, earlets, water tubes; a o d c, digestive system; r-r''' solid rods of the arms; m, mouth; b, madreporic opening. Fig. 107, f, brachilar appendages.

The pluteus, a nomadic stage of the echinus, is as Mr. A. Agassiz states "a scaffolding in which the future sea urchin plays but a secondary part, and is composed of two open spirals, the one to form eventually the complicated abactinal system (the interambulacral and ambulacral plates), the other to form the water system, and holding between them the digestive cavity and other organs of the pluteus, which as yet appear to have no connection whatever with the spines of the future Echinus. Yet towards the end of the nomadic pluteus life a few hours are sufficient to resorb the whole of the complicated scaffolding, which has been the most striking feature of the Echinoderm, and it passes into

Fig. 104.

Fig. 105.

Fig. 106.

Development of the Pluteus of the Sea Urchin.

something which, it is true, we could hardly recognize as an Echinus, yet has apparently nothing in common with its former condition."

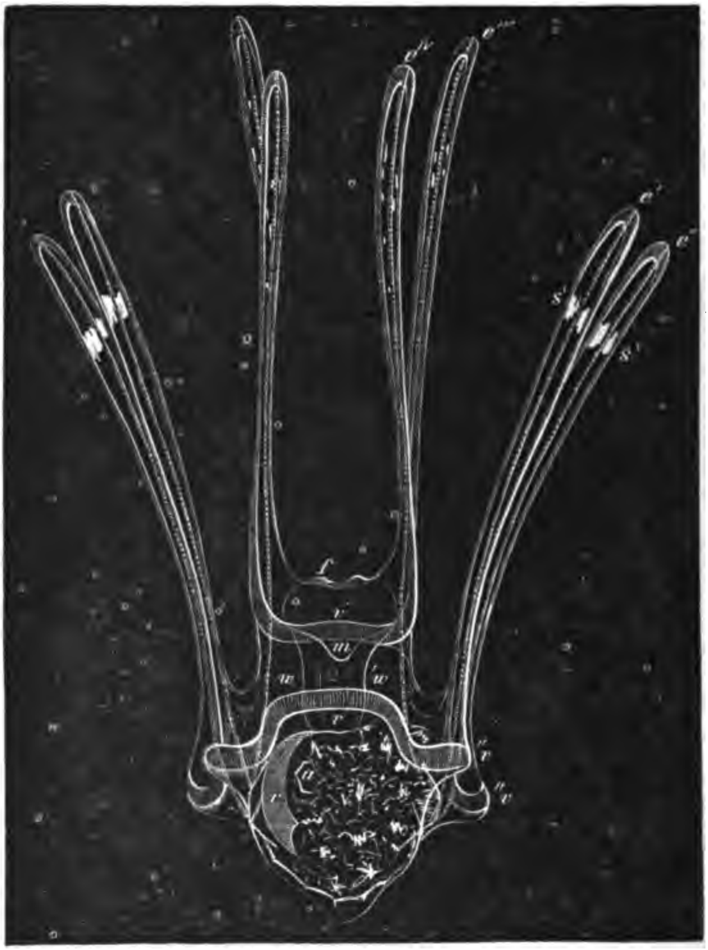
From this time the body of the pluteus is absorbed by the growing sea-urchin; the spines and suckers of the latter increasing in size and number with age, and by the time the larval body has disappeared the young Echinus is more like the adult than the starfish at the same period in life. Fig. 109 (*tt*, tentacles; *s''s'''*, spines) represents the sea urchin very soon after the resorption of the pluteus.

In after life the young sea urchin with its few and large spines resembles Cidaris and a number of allied forms, showing that

these genera, which appeared earlier geologically than our common Echinus (Fig. 103, *Strongylocentrotus Dröbachiensis*), are lower in development.

Development of the Holothuroids. Of the development of our

Fig. 107.



Plutcus of the Sea Urchin.

native sea cucumbers our knowledge is exceedingly fragmentary, and for nearly all that we do know of the mode of growth of these animals in general, we are indebted to the elabo-

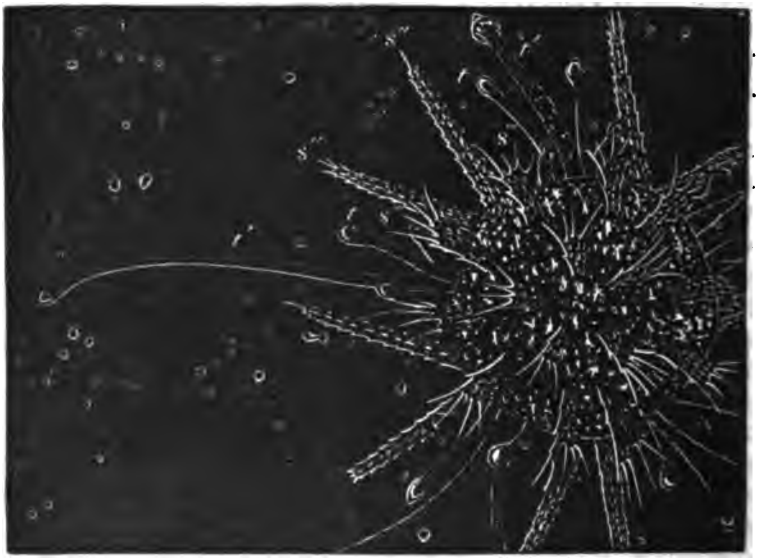
rate researches of the distinguished J. Müller. He figures the earliest stage of the larval Holothurian, which he calls an "Auricularia." The course of development is much as in the starfishes. The earliest stage known resembles that of the starfish represented by Fig. 93. It then passes through a stage represented by Fig. 96, when the mouth and digestive tract is formed, and again a stage analogous with Fig. 98. The Auricularia when fully grown, is cylindrical, annulated, with four or five bands of cilia, usually with ear-like projections, whence its name Auricularia. Before it becomes fully formed the young Holothurian begins to grow near the side of the larval stomach, the calcareous crosses appear and the tentacles of the future Holothurian bud out. The ear-like projections disappear, the Auricularia becomes cylindrical, and is now called the "pupa." The Auricularia is gradually absorbed and the young Holothurian strikingly resembles a worm. In this pupa stage, in certain transparent forms observed by Müller, the intestine of the embryo Holothurian could be observed twisted on itself, with the mouth surrounded by tentacles. The only observations published on our native Holothurians are those of Mr. A. Agassiz, on Cuvieria, our large red, heavily plated sea-cucumber, which inhabits stony bottoms in deep water. The young are of a brilliant vermilion. In the earliest stage observed by Mr. Agassiz (Fig. 110 *l*, "pupa;" *g*, tentacles);

Fig. 108.

Profile view of 107.

the "pupa" or second form of the Auricularia is very large and the tentacles do not project beyond the body, as they afterwards do (Fig. 111) when the Auricularia is nearly absorbed by the growing Holothurian. In a succeeding stage the tentacles begin to branch, where before they were simple and knobbed. At this time the œsophagus, stomach, intestine and anus are developed, and there is a ring of limestone rods and crosses around the mouth. The madreporic body (*b*) has not yet been drawn within the body.

Fig. 109.



The young Echinus.

Finally, the Auricularia becomes wholly absorbed, the tentacles are much branched and capable of retraction within the body; the tegument secretes limestone plates, the suckers are developed in the ambulacral rows and the adult form is attained without important changes. Fig. 83 represents a common sea-cucumber of our coast.

Some holothurians, as well as starfishes and ophiurans, as observed by Mr. A. Agassiz, undergo their larval (*i. e.*, Pluteus, Brachiolaria and Auricularia) phases of development above described without leaving the parent, in pouches held over the mouth of the parent, making their escape in a form approaching that of the adult.

Metschnikoff has made some valuable comparisons between the ciliated embryos of the Cœlenterates and Echinoderms, and shows that the primitive body-cavity of the former is not homologous with the peritoneal cavity (*i. e.*, the space in which the digestive canal hangs) of the Echinoderms. He also shows that while the primitive body cavity of the Cœlenterates remains permanently as the digestive tract; in the Echinoderms it is temporary and embryonic. Metschnikoff, on embryological grounds (a view which the structure of the adult animals confirms), thinks that there is the same similarity between the Cœlenterates (Acalephs and Ctenophoræ) and Echinoderms, as between the higher worms (Hirudineæ, Gephyrea and Annelides), and the Crustacea and Insects.

Fig. 112.

Larva of Cuvieria.

Reproduction by fission as in the Actiniæ and jelly fishes very rarely occurs in the Echinoderms. An Ophiuran deprived of all

Fig. 110.

Fig. 111.

Development of a Holothurian (Cuvieria).

its arms will reproduce them by budding, and Lütken shows that certain starfishes divide in two spontaneously, having three arms

on one side and three on the other, while the disk looks as if it had been cut in two by a knife, and three new arms had then grown out from the cut side.

Echinoderms as a rule, then, are reproduced alone by eggs and sperm cells. After fertilization of the egg they pass through:

1. Morula stage.
2. Gastrula stage.
3. A larval, temporary stage (Pluteus, Brachiolaria, Auricularia).
4. The Echinoderm grows from a water tube of the larva, finally absorbing the latter, whose form is often materially changed during the process. It thus undergoes a true metamorphosis, in a degree comparable with that of some insects.

LITERATURE.

J. Müller. Abhandlungen über die Metamorphose der Echinodermen. (K. Akademie der Wissenschaften. Berlin, 1848-1855).

A. Agassiz. On the Embryology of Echinoderms. (Memoirs Amer. Acad. Arts and Sci. ix, 1864.) Revision of the Echini, Part iv. (Ill. Cat. Mus. Comp. Zool. vii, 1874).

Wyville Thompson. On the Embryology of Antedon rosaceus. (Philosophical Transactions, London, clv. 1865).

REVIEWS AND BOOK NOTICES.

The Geological Survey of Missouri.—We have too long delayed our notice of the two octavo volumes from the geological survey of Missouri, which, though bearing the date of 1873, were not distributed till 1874. The first of these is a collection of reports from 1855 to 1871, by Messrs. Brodhead, Meek & Shumard, and the second, the results of the work of 1872, is devoted to the iron and coal deposits of the state. Of these the former are described by Dr. Adolph Schmidt, and the latter by Mr. Brodhead; in addition to which the late director, Prof. Raphael Pumpelly, has prefixed an important chapter on the geology of the Pilot Knob district, and its iron ores, from which, and from the copious descriptions of Dr. Schmidt, we gather a pretty complete account of this extremely curious region. Rising above the floor of horizontal palæozoic deposits, the 3d Magnesian limestone of Swallow, a member of a group of strata supposed to correspond to the Potsdam of New York, appear numerous hills of crystalline rock, described as exposed portions of the skeleton of the eastern part of

the Ozark Mountains; which formed an archipelago in the palæozoic sea, and are now from 300 to 700 feet above the limestone at their base. The Pilot Knob group includes four of these, and the Iron Mountain is another and distinct mass. All of these consist wholly or in part of quartziferous porphyry or orthophyre, but in the vicinity of these porphyry hills are others composed of granites, often chloritic or hornblendic, some of them capped by the porphyry which is considered as a newer rock, and, it is suggested by Pumpelly may be the youngest member of the Eozoic (Archæan) rocks of the region. He, however, adds in a note that the red granites may be an exception to this supposed rule. These porphyries present some considerable variations in character, but may be described as having a fine grained compact base or matrix with conchoidal fracture, composed of an intimate mixture of feldspar and quartz, in which are generally disseminated small crystalline grains of vitreous quartz, and crystals of pink or white feldspar, generally triclinic. The colors of this rock are various shades of yellow, red, gray, brown and black, and it is often banded in its structure, sometimes exhibiting thin layers, occasionally with alternations of quartz, in addition to which, according to Pumpelly, it is stratified on an immense scale. Epidote, chlorite and a steatitic mineral occasionally occur in it, and magnetic and specular iron ores are often disseminated through the mass. To those familiar with the geology of our eastern coast it is only necessary to say that these porphyries seem to be identical with those of Lynn, Saugus, Marblehead and Newburyport, Massachusetts, which are traced thence along the coast of Maine and New Brunswick, and are well developed about Passamaquoddy Bay, where they occasionally contain small deposits of iron ore. These porphyries have already been compared by Hunt with those of Missouri and with similar ones on the north shore of Lake Superior. As seen on the coast of New Brunswick, they are, according to him, intimately associated and interstratified with schistose rocks, supposed to be of Huronian age.[1]

At Pilot Knob, the excavations in the ore-deposit have exposed a considerable section of the strata, which dip at a moderate angle to the southwest, and consist at the base of several varieties of banded porphyry, one of these containing iron ore in grains and

[1] T. Sterry Hunt, Chemical and Geological Essays, p. 187

in streaks. Above these lies a thin layer of clay slate, followed by a great mass of bedded iron ore (about forty feet) divided into two parts by a layer of a few feet of clay slate, talcose in parts. The upper portion, which is thin-bedded and flag-like, is less pure than the lower, containing a considerable admixture of silicious matter, and is overlaid by about 100 feet of well-bedded conglomerate rock, consisting of pebbles or more or less angular fragments of porphyry and gray quartz, in a matrix of granular iron ore, occasionally with grains of quartz and a soft clayey matter. In the lower part of this the conglomerate character is less obvious, and it appears to be a uniform ore-bearing porphyry with thin layers of fine conglomerate. The iron oxyd is essentially hematite or peroxyd, but the rock possesses a decided magnetic polarity. While the great deposit of ore is here newer than the porphyry, and seems to be the cement of a conglomerate made up of the ruins of this rock, it is found in the Iron Mountain in this region, in veins intersecting a clayey material, which is nothing but the porphyry decomposed *in situ*. In a deeper cutting, however, the hard unaltered porphyry has been met with. Prof. Pumpelly calls attention to several curious phenomena dependent upon the decay of the crystalline rocks in this region. In some cases partial decomposition of the granites has left at their outcrop great polygonal rounded blocks, often hundreds of tons in weight. Elsewhere, the chloritic granites for fifty feet, and probably for many times that depth, are completely disintegrated and decomposed. In the case of the decayed porphyry of the Iron Mountain, the effect of the atmospheric waters upon this mass, "part iron and part clay," has been to remove the latter, so that when the mountain was first examined, it exhibited a layer of from four to twenty feet or more in thickness, of rounded masses and grains of pure compact red hematite or specular ore, with very little clay. This residual detritus, as remarked by Pumpelly, represents a great amount of porphyry decomposed and removed since the ore-veins bear but a small proportion to the whole mass of the rock. In the sediments around the base of the mountain are large stratified accumulations of similar detrital ore, which were washed down the slope and "concentrated by the waves of the Silurian ocean," thus showing the great antiquity of this process of decay.

The ore at Cedar Hill near Pilot Knob is compact, holding grains of limpid quartz, and has, according to Pumpelly, the as-

pect of a porphyry, in which the whole matrix has been replaced by iron ore. This forms irregular masses in ordinary porphyry, which in other localities contains iron ores highly manganesian, and even deposits of nearly pure oxyd of manganese. Crystals of orthoclase, feldspar and grains of quartz, are found imbedded in a compact manganese ore, which, according to Pumpelly, may be supposed to have replaced the matrix, leaving the crystalline elements intact, while in other portions the replacement has been complete, manganese-oxyd taking the place of the grains of quartz, and the feldspar crystals. With these manganiferous porphyries is associated carbonate of lime, sometimes forming layers of pink and greenish crystalline limestone several inches in thickness, interlaminated with a schistose jaspery or porphyroid rock. To account for these various associations, Prof. Pumpelly suggests two hypotheses, the one that the porphyry, both matrix and included crystals, may have been replaced by oxyd of iron or of manganese, and the other that the parent rock may have been a limestone, parts of which were changed into ore by a similar replacement, "while the porphyry now surrounding the ores may be due to a previous, contemporaneous or subsequent replacement of the lime-carbonate by silica and silicates." The important fact is noted that chemical analysis shows that the remaining porphyry, intimately associated with the ore, has undergone no change, but retains its normal constitution.

The ore-deposit of Iron Mountain is, according to Dr. Schmidt, a great irregular vein of specular ore, more or less split up, and including masses of wall-rock, but accompanied by numerous smaller veins. He supposes the ore to have been deposited in fissures in the unaltered porphyry, which was further cracked and fissured by the crystallization of the ore, while this was itself subsequently broken by the contraction and the decomposition of the porphyry; in fact, the angular fragments of ore in the latter can scarcely be otherwise explained. The writer can, from his own observations, bear witness to the careful statements of facts in the case of these curious ore-deposits as given in the present volume, and affirm that the singular perplexity of the phenomena at the Iron Mountain can scarcely be better described or explained than has been done by Dr. Schmidt. As regards the origin of the ore-deposits Dr. Schmidt considers the various hypotheses of igneous injection, of sublimation and of segregation, and rejects

them in turn, in favor of that of aqueous deposition from infiltrating waters. The ores at Shepherd Mountain are similar vein-deposits, but the porphyry is here seen in an undecayed state.

As regards the very unlike deposits of Pilot Knob, Dr. Schmidt accepts the first hypothesis of Prof. Pumpelly, and supposes that solutions, similar to those which deposited the ore in the fissures of the porphyries elsewhere, have here effected the conversion of the porphyry into ore. It is, as he admits, difficult to explain in this view, the removal of the resulting silicate of alumina, and not less difficult to explain the removal or replacement of the quartz, as supposed by Pumpelly. When we consider that iron oxyds are frequent elements in gneissic and other crystalline rocks, and that they have been directly deposited in later sedimentary formations, it will seem to many simpler to accept the hypothesis that these iron and manganese oxyds in the porphyries and conglomerate beds, instead of having come from the replacement either of feldspar and quartz or of carbonate of lime, may have been deposited as we now see them.

Besides these ores associated with the Eozoic rocks, Dr. Schmidt describes several other classes of iron-ore deposits, one of the most interesting of which occurs in the sandstones immediately above the 3d Magnesian limestone above named, and often fills small basins or excavations in this sandstone, nearly vertical walls of which are seen to limit the ore-deposit. The ore in these is stratified, and is often both overlaid and underlaid by beds of clay, flint and broken sandstone, and, it is suggested, may have been deposited in cavities produced by a subsidence of the strata into caverns in the limestone beneath. The ore is sometimes specular red hematite, and at other times limonite, occasionally also magnetite, and sometimes includes rounded masses of ferruginous limestone with crystals of iron-carbonate. This association leads Dr. Schmidt to suggest as an alternative hypothesis, that these deposits may have been formed by the transmutation of limestone deposits previously occupying these basins. To this class belong the ores of the Merramec district.

In the Carboniferous series again, deposits of red hematite ore occur in sandstone, forming nodular or concretionary masses or regular beds. In one locality also, we have here described a large cavern or sink in the Receptaculite limestone at the summit of the Trenton, in which occur stratified layers of hematite and limonite,

with more or less heavy spar, the whole capped by a bed of crystalline heavy spar, including galena. The 3d Magnesian limestone is also metalliferous, and holds in drusy cavities crystals of pyrite and chalcopyrite. It sometimes contains more than the proportion of magnesian carbonate required to form dolomite, a not very common circumstance.

The coal measures of the state, belonging chiefly to the great western coal-field, and occupying an area of nearly 23,000 square miles, are described by Mr. Brodhead with much detail. The coal seams are generally thin, though some in the lower measures occasionally attain four feet. Their local value is very great from the scarcity of wood, and we are told in one place of a seam of from ten to fourteen inches which is wrought, the coal being sold at the mine for twenty cents a bushel. In regions where the product commands so high a price even small seams are precious. The coal deposits of Lincoln county in the eastern part of the state, belong, unlike those just referred to, to the central or Illinois field, and present the unusual character of detached basins of coal, sometimes twenty-five feet in thickness, with little or none of the usually accompanying strata, occupying depressions or previously excavated basins in the Lower Carboniferous limestone. These basins are very limited in extent, and have but a local importance.

The discussions of the various points with regard to the economic geology of the state, the chemical investigation of its iron ores, and the valuable appendix or investigations on the strength of building materials, all of which show good and thorough work alike for science and for the material advancement of the state, would occupy too much of our space. Since the regretted resignation of Prof. Pumpelly, on account of ill health, the direction of the survey has been confided to Mr. Brodhead, whose report for 1873, we have just received and shall soon notice. The beautiful atlas of maps which accompanies the report of 1872 should not pass unnoticed. These maps are from the establishment of Mr. Julius Bien of New York, who, by the admirable style of his work, has put all students of geology and geography under obligations to him.—T. S. H.

Relation of British Wild Flowers to Insects.[1]—The author prefaces his little work with the information that his observations

[1] On British Wild Flowers considered in Relation to Insects. By Sir John Lubbock. Nature Series. With numerous Illustrations. London, Macmillan & Co. 12mo. pp. 179. 1875. Price $1.50.

and notes on this subject were originally prepared with the view of encouraging in his children that love of natural history from which he himself had derived so much happiness. A child can readily understand the happy and clear exposition of the subject contained in the pages of this most attractive book. And this is the way natural history should be presented to children. It leads them to take at once a lively interest in the doings of insects and plants, and is worth far more than formal introductions to zoology, just as one can learn more by watching the actions of a live bee or the growth of a plant, than by the inspection of dried specimens.

Children of maturer growth will be startled and set thinking by some of the conclusions of Sprengel, Darwin, Hermann Müller and our author. For example, we are told that to bees and other insects "we owe the beauty of our gardens, the sweetness of our fields. To them flowers are indebted for their scent and colour; nay, for their very existence, in its present form. Not only have the present shape and outlines, the brilliant colours, the sweet scent and the honey of flowers, been gradually developed through the unconscious selection exercised by insects; but the very arrangement of the colours, the circular bands and radiating lines, the form, size and position of the petals, the relative situations of the stamens and pistil, are all arranged with reference to the visits of insects, and in such a manner as to insure the grand object which these visits are destined to effect." The facts tending to substantiate these conclusions are presented by word and picture. We are confident that books like these are destined to revolutionize the study of biology in our schools.

Elements of Magnetism and Electricity.[1] — This compact little manual like the "Principles of Metal Mining," is an English reprint. It is printed with the object of aiding students to pass "in the first class in elementary stage of the government science-examinations." It will be a useful reprint in this country.

BOTANY.

Geographical Distribution of North American Ferns. — An interesting paper on this subject by Mr. J. H. Redfield appears in the Bulletin of the Torrey Botanical Club. The last volume contains an excellent photograph of the late Prof. Torrey.

[1] Elements of Magnetism and Electricity, etc. By John Angell. With 120 illustrations. New York, G. P. Putnam's Sons. 8vo, pp. 176. Price 75 cents. For sale by A. A. Smith & Co., Salem, Mass.

ZOOLOGY.

Flight of Vanessa Antiopa, Feb. 16th.—This afternoon one of our visitors saw a butterfly fluttering in the air. In a few moments it lit on the snow, and he, going to it, found it chilled, and brought it to me. The specimen answers in appearance to *Vanessa Antiopa*. The insect has been flying about a warm room this afternoon.

Considering the intensity of the cold for the past six weeks, and the fact that even to-day the thermometer has not marked 26°, and not a suspicion of dripping even on the south side of the house, I have considered the incident worth relating to you.—E. Lewis Sturtevant, *So. Framingham*, *Mass.*, *Feb.* 16, 1875.

Snails in Winter.—S. Clessin describes the habits of snails during the winter, their burying in the ground, often in crowds, the formation of the epiphragm, the interruption in the growth of the shell, etc. He thinks that slugs and fresh-water snails are less sensible to the influence of season, hiding themselves later in autumn, and coming forth earlier in spring than Helix and that young specimens are less sensible than older ones. C. B. Ver-Regensb (xxxi, pp. 114–130).—*Zoological Record for* 1872.

Filaria in the House Fly.—Prof. Leidy has recently found that the common house fly is afflicted by a thread worm, about a line in length, which takes up its abode in the proboscis of the fly. From one to three worms occurred in about one fly in five. This parasite was first discovered in the house fly of India, by Carter, who described it under the name of *Filaria muscæ*, and suggested that it might be the source of the Guinea-worm in man.

GEOLOGY AND PALEONTOLOGY.

The Musk Sheep fossil in Silesia.—According to Herr F. Römer, of Breslau, the skull of the musk sheep (*Ovibos moschatus*), the most Arctic herbivorous mammal, has been detected among fossils from the Pleistocene loams of Silesia. The discovery is of some interest, in consequence of the limited occurrence of this species in Germany, three localities only having hitherto yielded its remains.—*Academy*.

A Tertiary Gar Pike in France.—It seems to be proved beyond doubt that a true Lepidosteus lived in the waters of the Paris basin during the early Tertiary period. M. Paul Gervais has recently announced that the ganoid fish from the Paris beds, described by Agassiz as *Lepidotus Maximiliani* should be referred to *Lepidosteus Suessionensis.* This correction is based upon the recent discovery of abundant fish remains, including vertebræ, at Neaufles, near Gisors.—*Academy.*

Fall of Cosmical Dust on the Earth.—It has been ascertained by Nordenskiöld of Stockholm, that small quantities of a cosmical dust, foreign to our planet and containing metallic iron, cobalt, nickel, phosphoric acid, and also a carbonaceous organic matter, falls upon the earth along with snow or rain.—*Amer. Journn. Science.*

ANTHROPOLOGY.

An Indian Mill Seen in the Museum of Nassau, New Providence.—This important object was marked "Indian idol or stool." An image with a human face was carved on the centre of one end of its oval shape; this "stool," as it was marked, was hollowed out, increasing from its two extremities towards the centre, the carved head peering a little above the rim. It was supported by legs, was of wood, the workmanship of the extinct race that once inhabited the island. It was in a good state of preservation, which is no doubt owing to the antiseptic qualities of the air in the cave in which it was found, which preserved the wood, that may be three hundred years old. Many caves have been found in the Bahama Islands which, if they were not the dwellings of the former Indians, must have formed their temporary shelters, as many implements are found in them.

This supposed "stool" was nothing else than a mill; the Indians would not have bestowed so much labor upon a stool. It is, besides, too small for that purpose. The people of the Island possessed in those days tools made of bone or stone, therefore they would only make the articles that manufactured food or clothing, the Islands producing no stone hard enough to be formed into a mill. It is just the height required for a person sitting upon the ground, is much like those made of stone, and in use by the poor

people and Indians of Mexico. I am convinced that this article seen in the museum of Nassau, N. P., was used to bruise or grind the corn, seeds of plants, dried fish, etc., used as food by the ancient and now entirely extinct race. The female sitting upon the ground, takes the mill, places it between her legs; then taking a flat piece of very hard wood (or stone) which can be found upon beaches, she draws it backward and forward, bringing under it whatever is in the mill, which, by rubbing back and forth, is soon reduced to flour, or to any consistency the animal or vegetable substance was desired.— EDWARD PALMER.

MICROSCOPY.

POSTAL MICRO-CABINET CLUB.—A club for the circulation and critical study of microscopic objects has been formed, its design and methods conforming mainly to those of the very successful English club. The following rules have been prepared for the use of the organization, and Rev. A. B. Hervey, No. 10 North Second St., Troy, N. Y., has consented to act as secretary until the first regular election of officers. Applications for membership may be made to him or to the Editors of the NATURALIST.

Rules of the American Postal Micro-cabinet Club.

1. This club shall be called the American Postal Micro-cabinet Club.
2. Its object shall be the circulation, study, and discussion of microscopic objects.
3. Reliable persons accustomed to work with the microscope, and able to contribute to the usefulness of the club by sending good objects for examination, shall be eligible to membership.
4. Applications for membership may be made to the secretary, and should be accompanied by reference to some person, preferably a member of the club or a well known microscopist, who is acquainted with the applicant.
5. Names of applicants known to be eligible, shall be submitted to vote by the secretary, who shall send them around through the circuits in the letter packages. A four-fifths vote of all the members shall be necessary to election.
6. Members elect shall be notified of their election as soon as they can be placed in any circuit, either by the formation of new

circuits or by filling vacancies in old ones. They shall then, and during the first week of every January thereafter during their continuance in the club, send to the secretary, as annual dues, the sum of fifty cents. If this subscription should prove insufficient to defray the expenses of the club, the secretary, with the approval of the President and managers, may give notice of an increase to any required sum not exceeding one dollar per year.

7. The officers shall be a President, Secretary, who shall also act as Treasurer, and two managers. They shall be elected by ballot by a plurality of votes cast, blanks for that purpose being sent around by the secretary in January of each year.

8. The secretary shall arrange the members in sections of twelve members each.

9. He shall send a box capable of holding one dozen slides to the first member of each section. Each person shall, within four days of the date of receiving it, put in a slide, preferably one which illustrates some new result of study or method of preparation, and mail the package, carefully directed and stamped, to the name and address next below his own on the list of members of the section. After completing each circuit the box shall be returned to the secretary who shall start it on the next circuit. When it has completed the whole circle of all the circuits, it shall be returned to the first circuit again, when each member shall remove his own slide and replace it with another, mailing the box as before to the next member.

10. Slides placed in the box must contain no writing. Written labels should be soaked off or pasted over, and the slide designated by a number to correspond with the number of the owner in the list of members of the section.

The slides are to be very carefully packed in the box, to which is securely attached by a string, at a distance of two inches, a tag bearing a postage stamp and the address of the next member of the section. Nothing is to be placed around or upon the box which could invite a blow from the post office stamp.

11. If any member should receive a box too much damaged to be safely used, or containing broken or damaged slides, or not containing the full number of slides indicated by the accompanying memoranda, he shall at once notify the secretary and the member who last mailed the box.

If the loss cannot be adjusted by exchange between the owner

of the slide and the person who mailed it, the damaged slide shall be sent to the secretary who shall compensate the owner, to an extent not exceeding one dollar for any one slide, out of any unappropriated funds belonging to the club. Cash on hand and in excess of the estimated expenses of the current year shall alone be considered subject to this claim. Differences of opinion in regard to damages shall be referred to the President, whose decision shall be final.

12. At the same time with the box, and to the same address, shall be invariably mailed a letter-package containing a list of members of the section and of objects in the box, and blank papers for memoranda, remarks, questions and answers, notices of exchanges sought or offered, etc.; also, at the proper times, voting lists for election of officers or the transaction of other business. Everything contained in the letter-package shall be considered the property of the club, shall only be removed therefrom by the secretary and shall be by him filed or published as may seem most advisable.

13. The letter-package and the box of slides should accompany each other, and any member who does not receive either one within three days after the receipt of the other, shall promptly notify the secretary.

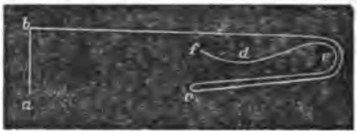
Notice shall always be sent by members to the secretary, one week previously, if practicable, of any change of post-office address, or of any absence from home which would cause more than ten days' delay in the forwarding of any package directed to them.

14. The secretary shall annually submit a detailed statement of receipts and expenditures to the managers, who shall audit the same on behalf of the club.

A NEW SPRING CLAMP FOR MOUNTING OBJECTS.—Mr. Norman N. Mason, of Providence, R. I., has contrived a clamp, or spring clip, for holding the cover-glass in position, which is probably by far the best yet made, both from the ease with which it can be made and the facility with which it can be used. A thin plate of sheet brass or German silver is cut to the shape of fig. 113, and then bent into position as represented in side view by fig. 114. The end of the glass slide is slipped under the spring *d*, and rests against the curve *e*. The point *a*, which may be protected with a

cork if preferred, rests upon the centre of the cover-glass. A little change in the curve of one or both of the plates at *e*, will give any necessary change of pressure upon the slide or the cover. An easy way to form this clamp is to cut strips of the metal as

Fig. 113.



Natural size.

long as from *a* to *f*, and as wide as at *c*. One is then bent upon itself at *c*, and hammered down flat; it is then filed, in a vice, with a uniform taper to *a*; the spring *d* is then bent up and the

Fig. 114.

Two-thirds natural size.

curve *e*, formed with a pair of wire-nippers, and finally the long, straight spring turned up at right angles at *b*. Fig. 113 is drawn to natural size; fig. 114 is two-thirds natural size.

PRESERVING ALGÆ.—Mr. Thomas Palmer contributes to "Science Gossip" his method of preserving algæ as microscopic specimens. The seaweed is first washed in fresh water, which is left running so as to be continually changed, until the salt is entirely removed. It is then partially dried with blotting paper, and preserved in pure alcohol until wanted for mounting. For mounting it is transferred through chloroform to balsam. This method sacrifices the color, a loss which is overcome by staining with a warm solution of logwood.

MOUNTING SELECTED DIATOMS.—F. Kitton highly compliments slides received from Herr Weissflog, in which the selected diatoms ("not arranged in patterns, the doing which is a shameful waste of time") are mounted on a thin cover and then inverted over a cell consisting of a thin silver disk, of the same size as the cover, and perforated with a small central opening, often as small as $\frac{1}{50}$ inch. The object in this tiny cell is easily found, stray light is largely cut off, and a very neat mount is produced.

A tinted Condensing Lens.— Prof. E. Abbe, of Jena, whose New Illuminating Apparatus seems not very unlike the common English "Webster Condenser" modified so as to be available in the limited space allowed between the stage and mirror in continental microscopes, suggests the employment as a condensing lens, when lamplight is to be employed, of a large glass globe filled with water colored of a moderate blue tint. This is placed between the flame and the plane mirror below the condenser, and gives, according to the depth of color employed, a nearly white or a decidedly blue illumination.

Wide Angled Objectives. — Having been a member of the committee of the Memphis Microscopical Society appointed to make certain tests of various object-glasses, it may prove of interest to make public the results of our investigations.

Dr. Carpenter lays down as a fixed law the statement that "all who have made much use of the microscope are now agreed as to the superior value of objectives of moderate or even comparatively small angle of aperture for ordinary working purposes ; the special utility of the very wide apertures being limited to particular classes of objects." (Carpenter, 4th ed., p. 172).

It is now claimed that this no longer holds good ; and our investigations were undertaken simply with a view to testing the correctness of this statement.

The glass we selected as the representative of the wide angles was a "four-system" immersion $\frac{1}{10}$th, of nearly 180°; the narrow angles with which it was compared were the best at our command, by leading makers of England, Germany, France and America, and comprised both dry and wet systems. Bearing in mind the theory that the wide angles are only superior on diatoms and with oblique illumination, we discarded diatom tests, and used only central light.

The first slide selected was a specimen of mosquito scales, dry. Under the $\frac{1}{10}$th of nearly 180°, this object was beautifully defined, the structure of the intercostal spaces, longitudinal ribs and terminal spines being all sharply and clearly shown. Even under so high eye-piercing as $\frac{1}{4}$th inch solid (equal to D), the object was splendidly illustrated. The narrow and moderate angles were then successively brought to bear on the same object, with the uniform result that while not giving so good definition under low power

eye-pieces, under the high eye-piece all utterly broke down. The next test selected was a slide of voluntary muscular fibre, in balsam. Here again the nearly 180° glass gave splendid results, the definition of the striæ being perfect even under D eye-piece. The moderate angles were again brought on the field, with the same result as before.

These facts seem to justify the claim that the law, as laid down, touching the general usefulness of the wide-angled glasses, is not now correct, having obtained credence at a period when the difficulties attending their construction had not been thoroughly mastered; but that such is no longer the case. I feel sure that the advanced workers of this country already accept as true the conclusions arrived at by our committee; but I am also sure that by far the greater number of our microscopists still hold to the old faith.—ALBERT F. DOD, *Memphis, Feb.*, 1875.

FREEZING APPLIED TO HISTOLOGY.—Messrs. Key and Retzius, while admitting the value of freezing as a means of hardening certain tissues for cutting sections, have lately called attention to the false canals which are often formed and which not only disorganize the tissue, but might be mistaken for normal structures. At the moment of freezing, the water separates from the tissues and branches out into acicular columns of ice; and the cavities thus formed may be preserved and demonstrated by hardening the frozen sections by alcohol or osmic acid, before thawing them. Exactly similar appearances may be observed in sections of frozen blood or starchy or gelatinous mixtures.

Mr. Lawson Tait, of Birmingham, has found sections of tissue, which were cut while hardened by freezing, to be full of air-bubbles which even the air-pump failed to remove. The contained water had, in freezing, expelled the air it had held in solution, and the bubbles thus produced were so entangled in the tissue as to defy mechanical treatment. They were readily re-dissolved, however, by soaking the section in cold distilled water which had been recently boiled to expel its supply of air.

EMBEDDING IN ELDER PITH.—Dr. C. H. Golding Bird, in a paper read before the Medical Microscopical Society, advocates elder pith as an almost universally preferable medium for embedding tissues preparatory to cutting sections. For holding in the hand it will in most cases give as good results, as the troublesome

wax method, and in far less time; while for use in the microtome it is preferable because of its simplicity and portability, no accessory appliances being required, because it cannot revolve in the microtome like wax, and because of the facility with which it can be removed from the tube and readjusted in it if required. The object, such as a piece of hardened tissue, is loosely packed in the tube of the microtome by means of dry elder pith which, being wetted, in about three minutes swells so as to fill up the vacant spaces and fixes the object immovably in place. This process which is represented as equal, in most cases, to the common method by wax or paraffine, is invaluable for cutting sections of leaves and the like, for which the usual embedding media are nearly useless. Even tissues embedded in wax may be conveniently packed in the microtome by means of pith.

NOTES.

An organization bearing the title of the "Central Ohio Scientific Association" was formed in Urbana, Champaign Co., O., in November last, with the following officers for the present year: President, Rev. Theo. N. Glover; Vice-President, P. R. Bennett, Jr.; Corresponding Secretary and Curator, Thos. F. Moses, M.D.; Recording Secretary, Wm. F. Leahy; Treasurer, J. F. Meyer.

The 22d of November, the block of granite which is designed to cover the tomb of the naturalist Agassiz, left Interlaken for Neuchâtel. It has been taken from the rocks situated below the glaciers of the Aar, near the hut where Agassiz and his colleagues in science explored the glaciers.—*Swiss paper.*

The Detroit "Scientific Association" has during the past winter held monthly meetings. The museum of the society is temporarily located in rooms. The officers for 1874–5 are G. P. Andrews, M.D., President; and A. B. Lyons, M.D., Secretary and Cabinet keeper. There are eight Curators.

The Geological Magazine edited by Henry Woodman, has just completed the first volume of the second decade since its first publication. This journal is of sufficient general and popular interest to secure subscribers in this country among geologists. The publishers are Messrs. Trübner & Co., of London. Subscriptions will also be taken at the Naturalists' Agency.

BOOKS RECEIVED.

U. S. Geological and Geographical Survey of Colorado, Report for 1873. By F. V. Hayden, Washington, 1874. pp. 718. 8vo.

Contributions to the Fossil Flora of the Western Territories. Part I. Cretaceous Flora. By Leo Lesquereux.

Reports of the U. S. Geological Survey of the Territories. By F. V. Hayden. Washington, 1874. Vol. vi, pp. 136. 4to.

Psyche. Cambridge, Feb. 1875. Vol. 1, No. 10, pp. 41-48. 8vo.

Canadian Entomologist. London, Oct. 1875. Vol. vii, No. 1, pp. 20. 8vo.

Monthly Report of the Department of Agriculture. Washington, Jan. 1875, pp. 68. 8vo.

Societe Entomologique de Belgique. Serie II, No. 8, Jan. 1875.

Preliminary Report upon Invertebrate Fossils Collected by the Expeditions of 1871, 1872 *and* 1873, *with Descriptions of New Species.* Geographical and Geological Explorations and Surveys West of the 100th Meridian. By C. A. White. Washington, D. C., 1874. pp. 27. 8vo.

Astronomical and Meteorological Observations made during the year 1872 *at the U. S. Naval Observatory.* By B. F. Sands. Washington, 1874. pp. 555. 4to.

U. S. Geological Survey of the Territories for 1867, 1868 *and* 1869. By F. V. Hayden. Washington, D. C., 1873. pp. 261. 8vo.

U. S. Geological Survey of Wyoming and Contiguous Territory, 1870. By F. V. Hayden. Washington, 1872. pp. 511. 8vo.

U. S. Geological Survey of Montana and Adjacent Territory, 1871. By F. V. Hayden. Washington, 1872. pp. 538. 8vo.

U. S. Geological Survey of Montana, Idaho, Wyoming and Utah. 1872. By F. V. Hayden. Washington, 1873. pp. 844. 8vo.

Supplement to the Fifth Annual Report of the U. S. Geological Survey of the Territories for 1871. By F. V. Hayden. Washington, 1872. pp. 22. 8vo.

Bulletin of the U. S. Geological and Geographical Survey of the Territories. Washington, 1875. 2nd Series, No. 1. pp. 47. 8vo.

Lists of Elevations Principally in that portion of the U. S. West of the Mississippi River. By Henry Gannett. Washington, 1875. pp. 74. 8vo.

The Elevations of Certain Datum-Points on the Great Lakes and Rivers and in the Rocky Mountains. By James T. Gardner. Washington, 1875. From Ann. Rep. U. S. Geological and Geographical Survey of the Territories for 1873. pp. 629-659. 8vo.

Meteorological Observations made during the year 1873 *and the early part of the year* 1874, *in Colorado and Montana Territories.* By George B. Chittenden. Washington, 1874. pp. 57. 8vo.

Synopsis of the Flora of Colorado. By Thomas C. Porter and John M. Coulter. Washington 1874. pp. 180. 8vo.

Contributions to the Extinct Vertebrate Fauna of the Western Territories. By Joseph Leidy. Washington, 1873. U. S. Geological Survey of the Territories. Vol. I. pp. 358. 4to.

Synopsis of the Acrididæ of N. A. By Cyrus Thomas. Washington, 1873. U. S. Geological Survey of the Territories. Vol v. pp. 272. 4to.

Magnetische und Meteorologische Beobachtungen an der K. K. Sternwarte zu Prag im Jahre 1873. By Carl Hornstein. Prag, 1874. pp. 86. 4to.

Acta Academiæ C. L. C. G. Naturæ Curiosorum. Dresden. Vol. 36. pp. 574. 4to.

Leopoldina. Dresden. Heft vii, viii and ix. pp. 120, 120, 120. 4to.

Memoires de la Societe de Physique et d' Histoire Naturelle de Geneve. Geneva, 1873-74 Tome 23, Part II. pp. 508. 4to.

Memoires de la Societe des Sciences Naturelles de Neuchatel. Neuchatel, 1874. Tome 4, Part II. pp. 144. 4to.

Denkschriften der Kaiserlichen Akademie der Wissenchaften. Mathematisch-Natur. Classe. Wien, 1874. Band 33. pp. 270. 4to.

Sitzungsberichte math.-naturw. Wien, 1873. I Abtheil, No. 8-10. II Abtheil, No. 8, 9, 10. III Abthiel, No. 6-8, 9-10, 1874. I Abthiel, No. 1, 2, 3. II Abtheil. No. 1, 2, 3.

Jahresberichte der Naturforschenden Gesellschaft in Emden. 1873. pp. 44. 8vo.

Verhandlungen der schweiz. naturf. Gesellschaft, Jahrg. 1871, 72, 73. pp. 431, 400. 8vo.

Societe Helvetique des Sciences Naturelles. 1872, Fribourg, 1873.

Sitzungsberichte der Gesellschaft zur Beforderung der gesammten Naturwissenschaften zu Marburg. 1866-1873. 8vo.

Jenaische Zeitschrift fur Naturwissenschaft. Jena, 1874. Vol. 8, New Series. Vol. 1, No. 4. pp. 481-578. 8vo.

Correspondenz-Blatt des zoologisch-mineralogischen Vereines in Regensburg. 27th year, 1873. No. 1, pp. 192. 8vo.

Bulletin de la Societe des Sciences Naturelles de Neuchatel. 1874. Tome, x, No. 1. pp. 205. 8vo.

Jahrbuch der k. k. geologischen Reichsanstalt. 1873, xxiii, No. 4. 1874. xxiv, Nos. 1, 2, 3. 4to.

Verhandlungen der k. k. geologischen Reichsanstalt. 1873, Nos. 14-18. 1874, Nos. 1-13. 4to.

Bulletin Mensuel de la Societe d' Acclimatation. Paris, Oct. 1874. 3e Serie, T. 1, No. 10. pp. 601-664. 8vo.

Diptera, or Two-winged Flies. By Townend Glover. Mss. Notes from my Journal, or Illustrations of Insects Native and Foreign. pp. 120. 4to. Washington, 1874.

Bulletin of the Torrey Botanical Club. Feb. 1875. Vol. vi, No. 2. With Supplement to Botanical Directory. pp. 8. 8vo.

Preliminary Report on the Cretaceous Lamellibranchs Collected in the vicinity of Pernambuco, Brazil. By Richard Rathbun. Boston, 1875. From Proc. Bost. Soc. Nat. Hist. pp. 241-256. 8vo.

Birds of the Northwest. By Elliott Coues. U. S. Geological Survey of the Territories. pp. 791. 8vo. Washington, 1874.

Constitution, By-laws, etc., of the Troy Scientific Association. Troy, 1875. pp. 11. 8vo.

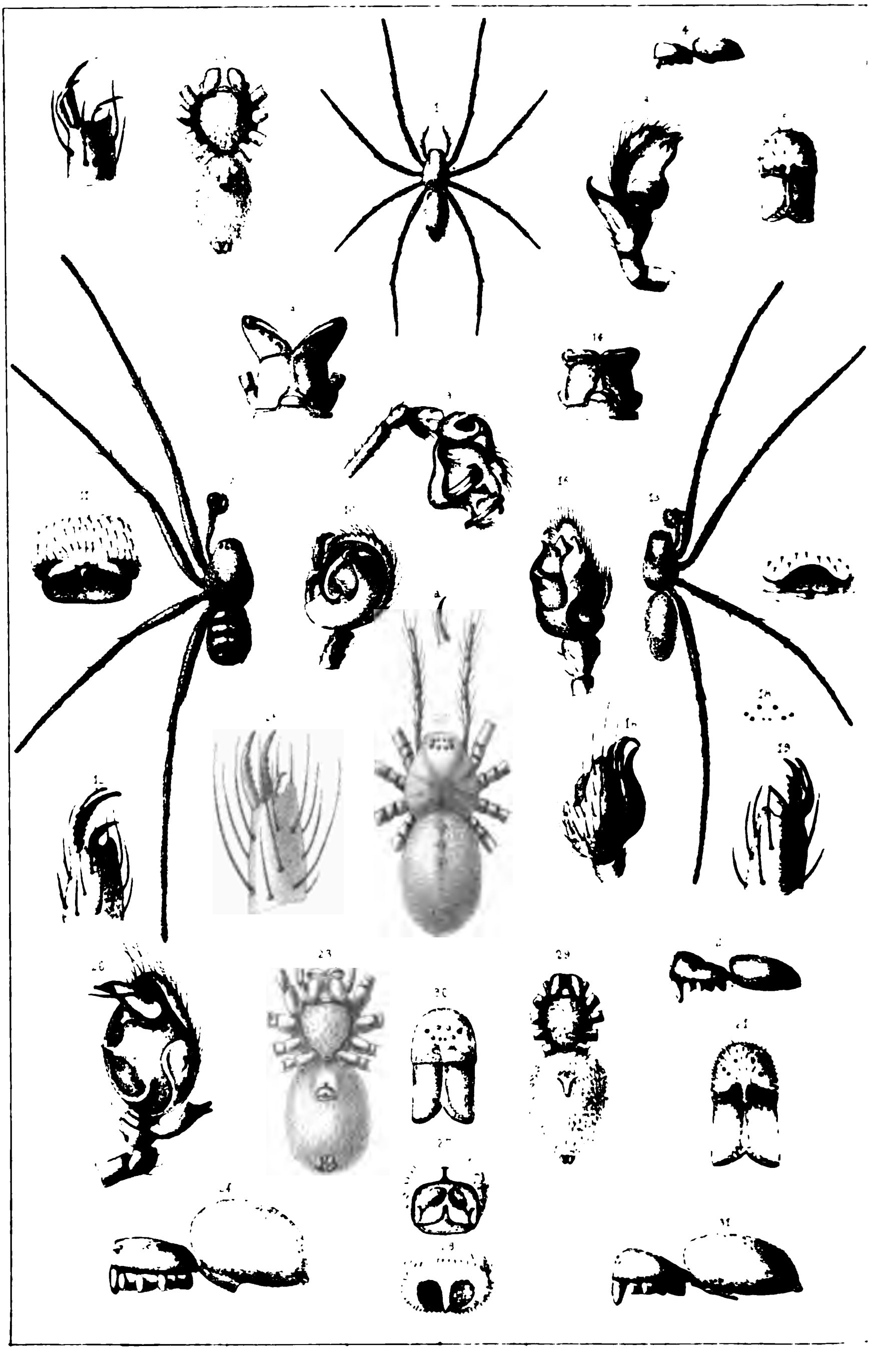
Views of Nature. pp. 141-188. Anonymous. 12mo pamphlet.

Report on the Gums, Resins, Oleo-Resins, and Resinous Products in the India Museum, or Produced in India. By M. C. Cooke. London, 1874. pp. 152. 4to.

Final Report of the U. S. Geological Survey of Nebraska. By F. V. Hayden. Washington, 1872. pp. 264. 8vo.

May

1875



Emerton, del. J. Mayer & Co. lith.

CAVE SPIDERS OF KENTUCKY, ETC

THE

AMERICAN NATURALIST.

Vol. IX.—MAY, 1875.—No. 5.

THE LAW OF EMBRYONIC DEVELOPMENT THE SAME IN PLANTS AS IN ANIMALS.

BY I. A. LAPHAM, LL.D.

It is a well known law in the animal kingdon, that the young or embryonic state of the higher orders of animals, resemble the full-grown animals of the lower orders. As examples, we have the tadpole, which is a young frog with gills and a tail, thus resembling the fishes which stand lower in the scale than the reptiles; and the caterpillar which has the characters of a worm, but is the immature state of the butterfly, an animal of a higher class of articulates. The discovery of this important law, and its application to particular cases, has been one of the causes of the recent rapid progress in the study of the animal kingdom; it has enabled naturalists to determine the proper place of certain species in the grand scale of beings, and thus to correct their systems of classification; it has enabled geologists to decide upon the relative age of rocks, in some otherwise doubtful cases.

It is the purpose of this paper, to show, as briefly as possible, that the same law of resemblance between the immature of one order and the mature of a lower order of animals, is equally true in the vegetable kingdom, where its study may hereafter lead to equally important results.

Plants grow from seed planted in the ground, have roots, stem, branches, leaves; they produce flowers with calyx and corolla, and the more essential organs, stamens and pistils; they bear fruit

with seed after their kind, which when planted, swell and become plants again.

The stamens have at their top a sack (the anther) completely filled with grains nicely packed, each of which proves on examination to be a small sack (Fig. 115, the pollen) filled with a viscous fluid matter, in which are floating exceedingly small grains called fovilla. These are essential organs in the reproduction of the plant, and must perform their functions before the seed can be matured. We may increase and multiply plants by layers, cuttings and budding; but to reproduce a new plant, the agency of the stamen, pollen and fovilla, is needed as well as that of the seed.

Fig. 115.

Pollen.

Under a good microscope, this fovilla may be seen in any ripe pollen grains, but the particles are among the most minute things we are called upon to examine; requiring the higher powers of the instrument even to see them; and, what is truly wonderful, these minute particles are found to have a proper motion of their own. They move forward, backward or sidewise, but never make much progress in any direction; the motion appears to be objectless, not like that of an animal seeking its food. The cause of this motion is not known; it is called molecular motion, and may be the effect of some chemical action; but is more probably due to the mysterious vital force.

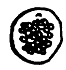
From the bottom of ponds of stagnant water, and from springy places, we may bring up plants so minute that no unaided human eye has ever seen them; they consist of a single cell; they are the smallest and the very lowest grade of plant-life, the Desmideæ; and yet they are full-grown plants. They never grow to be anything else, they are only Desmideæ and nothing more. They are true plants and not animals, as was once supposed.

These minute, though full-grown plants, will be found actively moving forward and backward and sidewise; making no progress; appearing to have no aim, no object; precisely like the little particles of fovilla from the pollen grains, of the highest orders of plants.

Here then we have the first proof of the existence of the law in the vegetable kingdom; the wonderful motion, both of the full-grown plant of the lowest of the vegetable race, and of the particles, which may be regarded as one of the first steps toward the reproduction of plants of the highest type.

Arctic and Alpine travellers report the snow as sometimes red, and we know that our stagnant waters are sometimes green; these colors are found upon close examination to be owing to other minute one-celled plants called Protococcus (Fig. 116). They are little sacks or cells containing particles of a brilliant carmine-red, or beautiful green color. Each particle within the cell is destined to become a new plant, and then again to give origin to others.

Fig. 116.

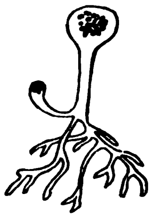


Protococcus.

The analogy between these full-grown plants of an exceedingly low grade and the pollen-grains (Fig. 115) of a rose, standing at or near the head of the plant kingdom, is at once apparent. They contain particles (fovilla) destined to the same office of reproduction; one woodcut serves to represent both.

The Botrydium (Fig. 117) may be deemed a plant only a little higher in the scale than the Protococcus. It consists like that of a single cell, but this cell sends down a tube which is often branched, extending off in various directions very much like roots in search of vegetable food. The cell proper is filled as usual with the reproductive particles; and some of the branches become enlarged as shown in the figure, develop other particles and soon separate to form new plants of the same kind.

Fig. 117.



Botrydium.

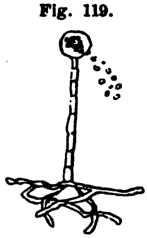
In this, and in many similar full-grown plants of the lower orders, there is a very striking correspondence with the pollen grains after they have fallen upon the stigma and developed tubes, the pollen-tubes (Fig. 118). In both cases we have a cell with a tube extending downwards from one side, with the vegetable particles and fovilla, and in both, these minute bodies are supposed to pass down the tube to perform their office of originating a new plant.

Fig. 118.

Pollen tube.

Here again the full-grown Botrydium corresponds with the embryonic pollen-tubes of the higher plants; and we have a third proof of the existence of the law.

Fig. 119.



Mould.

Fungi are plants of a higher grade than the Algæ, the Protococcus, and the Botrydium. Instead of a single cell, they consist of an aggregation of cells; and they produce a number of little cases or sacks filled with grains, called spores. Here (Fig. 119)

is the figure of the mould that grows upon bread in a damp cellar. It consists of a single stem made up of cells placed one upon the other, and a single globular spore-case at the top. The spores are liberated when ripe and are blown to the four quarters of the world by the wind. Wherever they alight, circumstances being favorable,—as bread in a damp cellar,—they grow and become mould again. Compare this, which is one of the lowest of the Fungi, with a stamen (Fig. 120) growing in one of the most perfect of flowers. It has its filament (stem) supporting a case or sack (the anther) filled with pollen-grains (which I compare with the spores of the fungi) and which, when fully mature are liberated and scattered about by the wind, or are carried by insects. Under favorable circumstances (falling upon the stigma) they also grow and become new plants.

Fig. 120.

Stamen.

These examples are sufficient for the present purpose; they show clearly the existence of this important law in the vegetable, as well as in the animal kingdom. Many similar analogies might be found throughout the whole course of vegetable life, were it desirable to pursue the subject. We have here one more link between the two great kingdoms of organized nature, and another proof of the unity of design of the Creator.

ON THE PHYSICAL AND GEOLOGICAL CHARACTERISTICS OF THE GREAT DISMAL SWAMP, AND THE EASTERN COUNTIES OF VIRGINIA.

BY PROF. N. B. WEBSTER.

This remarkable morass, situated partly in Virginia and partly in North Carolina, is about forty miles long and from fifteen to twenty-five miles wide. The earliest account of a passage through the swamp is by Col. Byrd, who surveyed the state boundary line in 1728. Until this time, Col. Byrd wrote in his journal "this dreadful swamp was ever judged impassable."

About 1755 a Scotchman named Drummond, discovered the pond now bearing his name, and which has since been immortalized by Moore as the "Lake of the Dismal Swamp."

In 1763, George Washington, then twenty-one years of age, penetrated the swamp and in his own language "encompassed the whole." He camped one night on the eastern border of the lake, which is about seven miles long and five in width, and in a morning ramble before breakfast, made the interesting discovery that the water of several very small streams ran *out* of, instead of *into*, the lake. Washington wrote to Hugh Williamson that he had no doubt the water was running into some of the rivers of Albemarle Sound. The youthful surveyor had in fact discovered the source of Northwest River which runs into Currituck Sound.

Washington also ascertained that the surface of the lake was nearly level with the western edge of the swamp and considerably higher than the eastern border, or in other words that the swamp was neither a *hollow*, nor a *plain*, but a *hill-side*. More careful measurements since have shown that the surface of the lake is twenty-one feet higher than mid-tide, and twelve feet higher than the eastern border of the swamp.

Com. Barron and others sounded across the lake and found the depth, in the middle, to be fifteen feet, with a bottom of swamp-mud, covered in some places with white sand. The soil, if soil it can be called, taken one foot below the surface, contains more than 96 per cent. of organic matter. Workmen in the swamp assert that they can run a pole down from ten to fifteen feet in this soft mud or sponge. This sponge is really a peat when taken near the surface, and has been used as fuel. Shaded and kept moist by the dense growth of ferns, reeds, and juniper trees, which with their long deep roots stand firm in the trembling mud, the annual accumulation of vegetable growth does not decay, but gradually aids in raising the level of this growing bog. But when the mud is thrown up in ridges by the excavations for ditches and canals, it soon disappears by a slow oxidation.

The trees of past centuries, buried in the swamp, as well as the present growth are of great value for shingles, staves, and other purposes where durability is desired.

During dry seasons extensive fires prevail, not only burning the vegetation above the surface but the peaty soil itself, leaving holes and large depressions sometimes two feet in depth.

In this way the lake was probably formed. It is not to be supposed that the bed of the lake was thus burned to the depth of fifteen feet, but that at some remote time, the large area of its

bed was burned so low, that the water from succeeding rains filled it to a depth too great to allow vegetable growth, and that each succeeding year added to the height of the banks or relative depth of the lake. The perpendicular banks of the lake and the charred stumps that have been formed at the bottom, confirm this supposition. There are many proofs that the water supply of the lake is from the rainfall on the swamp and not from springs at the bottom. The water is remarkably pure except from vegetable matter infused, which gives it the color of weak tea and the name of juniper water. It is considered the best water for long sea voyages. Contrary to popular opinion abroad, the interior of the swamp is a very healthful locality.

Lyell briefly refers to the swamp in his "Travels in North America," and of course sees a confirmation of his theory of coal formations, viz.—"That ancient seams of coal were produced, for the most part, by terrestrial plants of all sizes, not *drifted*, but *growing on the spot*."

That the Great Dismal was once much greater is evident from the deposits of peaty matter, swamp mud, and burnt stumps, below from twelve to fifteen feet of clay, at the distance of several miles from its present limits.

A specimen of charred wood was taken from a well about five miles from the swamp, and perhaps a mile from Suffolk, Va., on the line of the seaboard railroad. It was found as a part of a large stump, where it had grown in the midst of the black peaty soil, and below six and one-half feet of swamp mud, two feet of blue clay, and twelve feet of red clay. In the mud about the roots of the stump, white sand was found as at the bottom of the lake.

It is well known that the southeastern part of Virginia consists of two plateaus, one about eight or ten feet above the sea and the other from twenty-five to forty feet. The well referred to was dug near the eastern edge of the higher plateau, and the surface of the swamp forms an inclined plane from one plateau to the other.

This vast swamp appears to be retained above the level of the adjacent land in a way similar to the peat-mosses of Solway and Sligo, until they burst and overwhelmed the neighboring country. What known force but that combination of molecular forces known as capillarity can supply and sustain the waters of the lake and swamp above described?

THE FERTILIZATION OF CERTAIN FLOWERS THROUGH INSECT AGENCY.

BY THOMAS G. GENTRY.

IN the spring of 1873, a few seeds of *Cucurbita ovifera* were sown in a box which had been previously filled with rich earth from the woods. In course of time they germinated, producing thrifty plants. After the latter had attained suitable heights for removal, some were transferred to the garden, and the remainder were given to friends in the vicinity; a few of the latter found their way to a thickly-built up portion of Philadelphia, and trained to grace the walls of an outhouse. All the plants flourished and fruited abundantly. The city fruit was the exact similitude of the original, globular in configuration, with a small curved neck, and of a light yellow color with a circular patch of green upon the basal part. The country plants produced more than a dozen gourds to the vine, which differed very materially from the original in size, form, and color. With one exception they were globular in shape, attaining in some instances a circumference of nearly three feet, and of a deep rich gamboge color. The exceptional case was perceptibly flattened at the ends, and marked with alternate longitudinal broad bands of deep and light shades of green, affording a striking contrast in color to the others. There was particularly noticeable in the fruit, a very close resemblance in outline and color to the ordinary pumpkin, *C. pepo*, and, indeed, the flavor and thickness of the flesh were so pumpkin-like, as to convince one unfamiliar with the facts, that it was truly the case. Whence the difference between the city fruit and that matured in the country? I think it must be attributed to the agency of insects. Many of the Bombi, for instance, *Bombus pensylvanica*, together with the little honey bee, *Apis mellifica*, were observed on scores of occasions by the writer, to visit the female flowers of *C. ovifera*, doubtless, through mistake, fancying them to be the pollen-bearing ones, with their posterior *trophi* laden with yellow pollen-grains gathered from *C. pepo*. In alighting upon a flower, a Bombus could not avoid brushing its posterior limbs against the bilobed stigmas thereof.

Here, it is evident, is a case of hybridism brought about through

the agency of bees, whereby a cross between two closely-allied species has been effected in an eminently successful manner, if the size, quality, and profusion of the fruit are any criteria. In the city specimens, fertilization has undoubtedly been accomplished through wind-agency. It is extremely doubtful that bees could have taken any part therein, since it is a rare occurrence to meet with them in a compactly built city; their presence being rarely ever observed except where conveniences for nest-building and abundance of food are met with.

Bees were also noticed by the writer to visit the female flowers of *C. ovifera*, after having previously collected pollen from the male flowers of the same vine. From this and the preceding fact, it would seem that the pollen of a very near ally has sometimes a prepotent influence over the plant's own pollen.

In Gray's Manual it is affirmed that *C. ovifera* is probably the parent of *C. pepo*. That there is a close relationship subsisting between them amounts to a settled conviction in my mind. The perfect freedom with which *C. ovifera* receives the pollen of *C. pepo*, in preference to its own, is what I should expect, if the latter has been evolved from the former, which I presume to be the case.

Supported by a trellis in front of my door, there is growing a beautiful and thrifty vine of *Wistaria Sinensis*. When the season is favorable, it is an early bloomer, throwing out its lovely purple, pendent racemes, days in advance of its long, graceful compound leaves. Its flowers usually appear with the various species of Bombi, Xylocopa and Apis, and are sources of attraction to them when other and richer sweets are absent. During the last spring my attention was attracted to these flowers, by the incessant hum which always saluted my ears when returned from my day's labors.

From morning until night, as long as the flowers remained, these busy creatures were engaged. There were *B. pensylvanica*, *B. virginicus* Fab. (queens); *Xylocopa virginica* (female) and *Apis mellifica* (worker). After watching them on many occasions for more than an hour at a time, I was surprised to discover how few entered the flowers in front for the honey which they secrete. They almost invariably perforated the vexillum. Having witnessed this operation many times, I set to work finally, to examine each individual flower of many clusters. The result of my labor showed that nearly every flower had been thus perforated. Judging from the sizes of the apertures, they were evidently the work of the

Bombi and Xylocopa; the proboscis of the honey-bee being too small and narrow to produce such results. Although hundreds of honey-bees were flying from flower to flower, not a solitary individual was noticed to enter the throats of the same. Like their larger and distant relatives, they took the shorter road. As a general rule, the little Apis enters in front. In this instance I can only attribute its deviation from custom to the power of imitation. Perceiving that the coveted material was to be had, at a great saving of labor and time, as evidenced by the examples of Bombus and Xylocopa, it had learned to profit thereby.

Although the purpose for which nature had created the flowers of Wistaria seemed to be defeated, viz., the propagation of its kind and the continuance of the species, as made manifest through previous observations, yet I did not cease to give them attention when opportunities offered. After long and weary watching for nearly one whole afternoon, I was repaid for my patience and watchfulness, by witnessing an individual of *Bombus pensylvanica* enter a flower. After this I had the gratification of witnessing similar operations performed by several others.

In order that the process may be understood, it is necessary to give a detailed description of the structure of a normal flower. In *papilionaceous* flowers, the corolla is perigynous; of five irregular petals (rarely fewer). The upper or odd petal, called the *vexillum*, is larger than the others, enclosing them in the bud, and when open is usually turned backward or spreading. The two lateral ones are called the *wings* and are situated obliquely and externally to the two lower petals; the last are connivent and more or less coherent by their anterior margins, forming a body named the *carina* or keel which usually encloses the stamens and pistil. The stamens are ten in number, diadelphous; nine in one set, in a tube which is cleft on the upper side, that is, the side next to the *standard*, and the tenth or upper one separate.

From the position of the stamens and pistils in a normal flower, the former being curved forward and overhanging the latter, it would seem that the object to be attained is the fertilization of the flower by its own pollen. But a knowledge of the degree of perfection to which the sexual parts have attained, after the release of the wings and carina from the enveloping vexillum, dissipates any such opinion. The anthers have not acquired their full development, while the stigma is perfect, judging from the viscid secre-

tion which covers its surface. By the time the anthers mature, the stigma has begun to wither. As the lower flowers of a cluster come to perfection before the upper ones, or rather as flowers may be found on the same raceme in various stages of development, it is possible to meet with some that mature their pistils at the same time that others do their stamens. It is obvious from the above that self-fertilization is out of the question. In confirmation thereof, I might cite the important fact that on a vine that produced no less than one hundred clusters, each bearing at least fifty flowers, but eight legumes were counted; seldom more than one was found on the same flower stalk; in one case I observed two.

When a Bombus visits a flower, it alights upon the *vexillum*, and in order to get to the honey, thrusts its proboscis downward between the *keel* and *standard* which are in close contact. The effort thus expended forces the carina backward which releases the second set of stamens and the pistil (the first being already free) from their confinement. The pollen-grains being already ripe, become dislodged from their box-shaped anthers, and fall down upon the head and back of the bee. The bee passes to another flower, further up on the same stem. The same process is effected, which permanently releases the stamens and pistils (the former being undeveloped). In the act of retiring, the head and sometimes the back come into contact with the stigmatic surface of the pistil which projects slightly beyond the stamens, and which being abruptly curved downward, cannot escape fertilization.

At the time of writing, June 29, 1874, a second crop of flowers is visible. These are principally secondary clusters, which have pushed from the long, pendent compound leaves, which are to be observed at the basal third of the primary floral axes. For more than a week I have attentively watched these flowers, in the hope of witnessing the visits of bees. Up to the present moment it has not been my privilege. Bombi pass and repass without being attracted. Within the woodwork of the trellis which supports the vine, are several burrows of *Xylocopa virginica*, and within a few inches of the aperture which forms the mode of ingress and egress, there is hanging a cluster of flowers, whose conspicuous color of purple and strong fragrance could not fail to invite attention and induce acceptance, were there a disposition upon the part of this insect.

When the clovers, particularly *Trifolium prætense*, are in blos-

som, and the delicious sweets which they yield are eagerly sought after, all other luxuries are held at a discount. Bees appear to be very fastidious, so to speak, in their tastes; seldom noticing plants of inferior qualities, except as necessity demands.

July 14th. The flowers have all fallen and not a legume, nor the trace of one, from this second flowering is to be seen. During repeated examinations of these secondary clusters, there was observed nothing in the structure of the stamens and pistil of any flower, to prevent self-fertilization, provided they had come to maturity at the same time. There was abundance of pollen in the anthers, and the stigmatic surface of the pistils was open and coated with a viscid secretion. The presence of bees and the development of fruit in a few instances where aided by those insects, associated with the opposite condition, to wit, the absence of bees and the consequent absence of fruit, the flowers being ready but the bees being unwilling, are incontrovertible evidence of the fact that bees are essential to the fertilization of *Wistaria Sinensis.*

BOTANICAL OBSERVATIONS IN SOUTHERN UTAH.

BY DR. C. C. PARRY.

No. 4.

The following list comprises the collection of plants made in the above district, in the season of 1874.

The numbers given correspond to those affixed to the distributed sets, and referred to in the previous papers. Where no numbers are given the plants named were either scantily collected, or merely observed. In a few instances the unnumbered plants, though belonging to this locality, were derived from other sources as indicated in the text. Where no special locality is given, the valley of the Virgen in the vicinity of St. George is to be inferred. To the notes and descriptions following any particular species furnished by other collaborators, the name of the author is appended.

No. 1. *Anemone decapetala* L. Rocky ledges. April.
No. 2. *Ranunculus Andersonii* Gray, Var., *tenellus* Watson. King's Rep. p. 7, t. 1.

Forming small clumps, with the flowering stems quite constantly branched; Beaver-dam Mts. May.

No. 3. *Delphinium azureum* Michx.

No. 4. *Myosurus aristatus* Benth. Santa Clara. May.

No. 5. *Berberis Fremontii* Torr. Beaver-dam Mts. May.

No. 6. *Arctomecon Californicum* Torr. Fremont's Rep. p. 312. t. 2. Dry gypseous hills on the Virgen. May. Differs from the description and figure above referred to, in its less hairy foliage, 4 (not 6) valved capsule, and white flowers; apparently biennial.

No. 7. *Eschscholtzia Californica* Cham., var. *hypecoides* Gray.

No. 8. *Platystemon Californicus* Benth. Upper Santa Clara. June. The most eastern locality from which this well known Californian plant has been collected.

No. 9. *Arabis longirostris* Watson. King's Rep. p. 17, t. 2.

No. 10. *Streptanthus cordatus* Nutt. Beaver-dam Mts. May.

No. 11. *Draba cuneifolia* Nutt. Rocky ledges. April.

No. 12. *Capsella divaricata* Walp.

No. 13. *Thysanocarpus curvipes* Hook.

No. 14. *Physaria Newberryi* Gray. Bot. Ives', Rep. p. 6. This species seems to take the place of the more common northern species, *P. didymocarpa* Hook., in all the mountainous districts of Southern Utah.

No. 15. *Biscutella (Dithyrea) Wislizeni* Engel. Sand drifts.

No. 16. *Lepidium integrifolium* Nutt., var. *heterophyllum*. Leaves more or less serrate or pinnatifidly lobed.—The present specimens have the leaves coarsely toothed, in the lowermost somewhat lobed, the upper being entire. No. 122 Watson (*L. montanum*, Var. (?) *alpinum*, King's Rep. p. 29), is a more extreme form with most of the leaves lobed. In every other respect the plant is exactly Nuttall's *L. integrifolium* (51 Vasey; 620 Wolf) which has leaves only few-toothed at the apex or entire. The species is provided with a somewhat woody base and thick leaves, glabrous, the petals conspicuous, capsule ovate to orbicular, marginless or very nearly so. Rocky ridges near Cedar City. July.—S. WATSON.

No. 17. *Lepidium Fremontii* Watson. King's Rep. p. 30, t. 4. Profusely branched from a perennial woody base, forming diffuse globular shaped clumps, 1-2 feet in height, with copious racemes of small white flowers, succeeded by crowded clusters of slender pedicellate, broadly obcordate siliques. The figure above referred to in Watson's Report, taken from an imperfect fragment, does not do justice to this fine well marked species. Abundant on rocky hill sides near St. George, flowering in May.

No. 18. *Lepidium montanum* Nutt.

No. 19. *Lepidium Wrightii* Gray. Siliques more glabrous than in the typical specimens.

No. 20. *Arenaria Fendleri* Gray, Var. *glabrescens* Watson. A much finer plant than the more common northern form and admirably adapted for ornamental rock work.

No. 21. *Stellaria Kingii* Watson King's Rep. p. 39, t. 6, fig. 1-2. Interior basin of Central Utah. July.

No. 22. *Lewisia brachycalyx* Engelm.

No. 23 and 24. *Claytonia perfoliata* Don., Vars. Shaded crevices of Sandstone rocks. Santa Clara. April.

No. 25. *Sphæralcea Emoryi* Torr.

No. 26. *Malvastrum exile* Gray. Bot. Ives's Rep. p. 8.

No. 27. *Glossopetalon spinescens* Gray. Pl. Wright. Pt. 2, p. 29, t. 12. Beaver-dam Mts. May.

No. 28. *Larrea Mexicana* Moric.

No. 29. *Acer grandidentatum* Nutt.

No. 30. *Vitis Arizonica* n. sp. Young branchlets, leaves and inflorescence densely floccose-tomentose, adult naked or usually (at least on the nerves of the leaves) beset with short hairs; leaves (small) orbiculate, cordate, with a wide (sometimes very broad) sinus, acute, with irregular, sharp, often very pointed, rather small teeth; rarely 3-5- lobed with rounded sinuses; tendrils intermitting,[1] branched; fertile inflorescence

[1] *Intermitting* tendrils we find in those species of *Vitis* where two leaves with opposed tendrils are succeeded by a third leaf without a tendril, and so on in succession:

and bunches of berries shorter than leaf; berries small or middle-sized (2–3½ lines in diameter); seeds mostly 2–3, usually obtuse with a small but prominent chalaza and more or less indistinct raphe. *Vitis æstivalis*, Var? Gray, Pl. Wright, pt. 2, p. 27. Torrey Pac. R. Rep. 7, Bot. p. 9.—Common along the streams of Arizona where it was first collected by the botanists of the Mexican Boundary, and of some of the Pacific Railroad Expeditions; later by Dr. Palmer, who made an especial study of it and gathered numerous specimens in mature fruit; Dr. Parry's collections are from southwestern Utah.

With some hesitation I venture to introduce a new species in this intricate genus, and especially in the Cordifolia group; but as this form cannot well be united with any of its allies, it will have to try and stand for itself. The forms belonging to the Cordifolia group are distinguished by their more or less entire leaves and small berries; they extend over the whole breadth of the continent from northeast to southwest, and are *V. cordifolia* with larger, broadly dentate, glabrous leaves and smallest berries in larger bunches, raphe usually strongly developed on the top of the seed as a well marked cord; from New England to Missouri, Nebraska and Texas; *V. riparia* with larger, incisely dentate, usually sharply 3-lobed, glabrous leaves, larger berries in small bunches, raphe slightly visible on top of seed; from Canada to the Rocky mountains and to Texas; *V. Arizonica* with smaller, broadly cordate, sharply dentate leaves, floccose at first, glabrous afterwards, middle-sized berries in small bunches, raphe more or less indistinct on top of seed; *V. Californica* with middle-sized, narrowly cordate, broadly dentate, always tomentose or canescent leaves, small berries in large bunches, raphe invisible on the broad seed; found only on the Pacific slope, from the Sacramento valley southward.

The fruit of *V. Arizonica* belongs like that of *V. riparia* to the better class of American grapes; while that of the two others is scarcely edible, this is said to be quite luscious, and will in time no doubt be cultivated, in a warmer climate. Dr. Palmer's seeds have well germinated with me, but the vines perished in the climate of St. Louis, after a lingering existence of several years. The seeds show a remarkable variability in form and markings so as to weaken to some extent their specific value. I find them generally obtuse, but emarginate and even notched on top; the chalaza is small but usually quite prominent and is narrowed upwards into the raphe, which on the top of the seed becomes inconspicuous, or in some instances remains quite prominent.

Dr. Parry's specimens from southwestern Utah are distinguished from all the Arizona specimens I have seen, by having somewhat lobed leaves. Their sterile flowers exhibit the usual form; longer anthers on long straight filaments, which in the bud are inflexed; in the fertile flower-bud the stamens are shorter than the pistil, the filaments straight and scarcely as long as the short anthers, and after fecundation recurved. I could discover no difference in the condition of the pollen of both kinds of flowers. This seems to be the ordinary form of the fertile flowers in our wild species, and in some cultivated ones, while some other stocks bear fertile flowers with long stamens, thus constituting the incompletely polygamous character of our grape-vines; purely pistillate flowers I have never seen, and doubt whether they exist.—Dr. G. Engelmann.

No. 31. *Krameria parvifolia* Benth.

No. 32. *Polygala subspinosa* Watson. Am. Nat. Vol. vii, p. 299. Cedar City. July.

No. 33. *Vicia exigua* Nutt.

No. 34. *Trifolium Kingii* Watson. King's Rep. p. 59. Intermediate in some respects between *L. Bolanderi* Gray, and *S. Beckwithii* Brewer.

No. 35. *Trifolium eriocephalum* Gray. Sheep range, Cedar City. July.

No. 36 and 38. *Hosackia rigida* Benth, Vars.

No. 37. *Hosackia rigida* Benth.

No. 39. *Hosackia subpinnata* Torr. & Gray.

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the ordinary occurrence in all our grape-vines with the exception of *V. Labrusca* and its cultivated varieties; in these the tendrils are *continuous*; *i. e.*, each leaf has a tendril opposed to it; all this only in well-grown canes. This character distinguishes at once all forms of *Vitis Labrusca*. *Branched* tendrils are found in all our species, with the exception of *V. vulpina*, which bears *simple* tendrils.

No. 40. *Dalea Johnsoni* Watson. King's Rep. p. 64.

No. 41. *Lupinus pusillus* Pursh. An unusually robust and showy form, frequently branching; 4–8 inches high.

No. 42. *Lupinus brevicaulis* Watson. King's Rep. p. 53, t. 7.

No. 43. *Lupinus (Platycarpos) Sileri* Watson. Proc. Am. Acad. vol. x, p. 345. N. sp. Low, caulescent, branching, loosely and softly villous; leaflets 5, oblanceolate 5–8 lines long, acutish, smooth above, shorter than the slender petioles; racemes short, few flowered, on elongated peduncles equalling the leaves; pedicels short, scattered; bracts shorter than the calyx; bractlets linear; calyx-lobes herbaceous, toothed, 3 lines long, the upper a little shorter; petals light-purple, 3–4 lines long; pod 4–5 lines long; seed a line or more broad.

An interesting addition to this section of the genus, distinguished readily from *L. pusillus*, by its more slender habit, softer pubescence, and capitate long-peduncled racemes. Washington Co., S. Utah (A. L. Siler, 1873); Loma on the Rio Grande, S. Colorado (195 Wolf). S. WATSON. Pine valley, S. Utah (Parry 1874).

No. 44. *Astragalus eriocarpus* Watson. King's Rep. p. 71.

No. 45. *Astragalus arrectus* Gray. Beaver-dam Mts. May.

No. 46–49. *Astragalus cyaneus* Gray. Pl. Fendl. p. 34. This species seems to be well distinguished from *A. Shortianus*, to which it has been referred, by the legumes which are broadest near the middle and more or less attenuate into the calyx especially when immature, and by the narrower oblong acutish leaflets. In *A. Shortianus* the wider pod is rounded at base and strictly sessile, the leaves suborbicular, mostly obtuse or retuse, and the pubescence of the calyx not closely appressed as in the other. *A. Shortianus* has been collected in the mountains of Colorado; *A. cyaneus* in New Mexico and Arizona. S. WATSON.

No. 47. *Astragalus atratus* Watson. King's Rep. p. 69, t. 11.

No. 48. *Astragalus diphysus* Gray. Cedar City. July.

No. 50. *Astragalus Nuttallianus* DC. Var. *canescens*.

No. 51. *Astragalus megacarpus* Gray, Var. Cedar City. July.

No. 52. *Astragalus lonchocarpus* Gray. Cedar City. July.

No. 53. *Astragalus Sonoræ* Gray. Cedar City. July.

No. 54. *Astragalus Kentrophyta* Gray. Cedar City. July.

No. 55. *Oxytropis campestris* L. High mountains near Cedar City. July.

No. 56. *Prunus (Emplectocladus) fasciculata* Gray, Proc. Am. Acad. Vol. x, p. 70. *Emplectocladus fasciculatus*, Torr. Pl. Frem. in Smith's contr. p. 10, t. 5. Abundant on all rocky slopes in the valley of the Virgen; fl. April; fr. June, popularly known in this section as "the wild almond."

No. 57. *Coleogyne ramosissima* Torr. Pl. Frem. in Smith's Contr. p. 8, t. 4. Flowering in May, fruiting in June. A very common shrub on the hills near St. George; foliage deep green; flowers bright yellow, copious. The mature fruit is said to be greedily browsed on by sheep who thrive on it.

No. 58. *Cercocarpus ledifolius* Nutt.

No. 59. *Cercocarpus intricatus*, n. sp. Watson, Proc. Amer. Acad. vol. x, p. 346. (*C. breviflorus* of King's Rep., p. 83, not of Gray). Cedar City. July.

No. 60. *Cowania Mexicana* Don.

No. 61. *Heuchera rubescens* Torr. Stansb. Rep., p. 388, t. 5.

No. 62. *Ribes viscosissimum* Pursh. Pine Valley. June.

No. 63. *Œnothera albicaulis* Nutt., var. (?) *decumbens*. Low, sending out from the base decumbent naked branches; leaves oblong-lanceolate, petioled, sinuate, dentate; common in dry, sandy soil near St. George. — WATSON.

No. 64. *Œnothera Johnsoni* n. sp. Resembling *Œ. primiveris*, but the flowers large and yellow, and the stigmas elongated. Petals one inch long, the calyx-tube equalling or exceeding the leaves; capsules 9–12 lines long, somewhat 4-angled, strongly nerved, not crested. Common on all dry hills near St. George. Dedicated to I. E. Johnson, Esq.

No. 72. *Œnothera (Chylismia) Parryi*, n. sp. Low, diffusely branched from the base, villous with spreading hairs; stems leafy; leaves ovate to oblong-lanceolate, ½–1 inch long, sub-sinuately toothed, cuneate or sometimes cordate at base, upon a slender, often

elongated petiole; the slender branches and petioles subtended by small sessile bracts; flowers deep yellow or orange, occasionally spotted with red inside, 3-4 lines broad; calyx-tube ½ line long, narrow, the tips of the lobes not free; capsule smooth, 4-6 lines long, ascending upon the more or less deflexed slender and often elongated pedicel.—Distinguished from any form of *Œ. scapoidea*, by its smaller capsules, more deflexed pedicels, bright yellow flowers and peculiar habit. Abundant in bare gypseous clay hills near St. George; fl. May.—S. WATSON.

No. 73. *Œnothera brevipes* Gray. Very variable in size, from 4 to 18 inches high. Rocky hill-sides near St. George; fl. May.

No. 74. *Œnothera brevipes* Gray, var. *parviflora*. Of a much more branching habit than the preceding; the leaves more distinctly pinnate; inflorescence more slender; flowers pale yellow, the petals 2-3 lines long.—S. WATSON.

No. 75. *Petalonyx Parryi*, n. sp. Gray, Proc. Amer. Acad., vol. x, p. 72. Frutescent, branches leafy up to the condensed spicate heads of flowers; lower leaves oblong or spatulate, entire, sub-sessile, upper ones larger, rhomboid obovate or ovate, crenate, acute at base, short petiolate; lobes of the calyx linear, twice as long as the ovary, a little shorter than the yellow unguiculate petals. Closely resembling *P. nitidus* Watson, of southern Nevada. A low branching suffrutescent plant with copious remains of dead stalks and faded leaves of a pearly white color. Found at only a single locality near St. George; fl. June.

No. 76. *Mentzelia multiflora* Nutt. The common form.

No. 77. *Mentzelia multiflora* Nutt. Var.

No. 78. *Mentzelia multiflora* Nutt. Var. (?). See above page 19.

No. 79. *Mentzelia (Kucnide) urens* Parry. Gray, Proc. Amer. Acad., vol. x, p. 71. Sub-erect, branching, very hispid with stinging bristles intermixed with smaller, many-barbed hairs; leaves orbicular, unequally sub-dentate, penninerved, lower petiolate, upper sessile, partly clasping at the base; peduncles and pedicels short, sub-corymbose; flowers large, petals light yellow, obovate, mucronate, often tipped with a small tuft of hairs, nearly twice as long as the lanceolate lobes of the persistent calyx, deciduous at maturity in a single piece with the very numerous stamens and united filaments forming an internal corona. Sub-pendent from crevices of perpendicular sandstone rocks on the Santa Clara; fl. June.

Mentzelia (Bartonia) tricuspis n. sp. A span high, rather stout, sparsely hispid with slender, simple bristles, and roughish with the shorter and peculiar pubescence of the group; leaves petioled, oblong-lanceolate, acute or acuminate, sinuately pinnatifid-toothed; flowers very short-peduncled, large; calyx bracteolate, its lanceolate subulate lobes about the length of the turbinate tube, and half the length of the 5 spatulate-obovate, light yellow petals; stamens very numerous, all nearly alike and antheriferous, rather shorter than the calyx; filaments narrowly linear, slightly dilated upwards, white with an orange colored base near the tricuspidate apex, the subulate lateral cusps sterile, and twice the length of the middle one, which bears the oblong-linear anther; style 2-cleft; ovules pretty numerous, apparently in two series on each placenta. Apparently annual, only a single specimen brought by the mail-rider from the desert districts south of St. George. May.—A. GRAY.

No. 80. *Cymopterus purpureus* Watson. AM. NAT., vol. vii, p. 300.

No. 81. *Myrrhis occidentalis* Benth. & Hook. High mountains near Cedar City. July.

No. 82. *Ligusticum scopulorum* Gray. Proc. Am. Acad.. vol. vii, p. 347. Elevated sheep ranges of the Wahsatch near Cedar City; July. The remarkable persistence of this species in the locality indicated, where it is found covering extensive tracts to the exclusion of other more nutritious vegetation—one of the few native plants that can maintain and even extend its foothold under the usually destructive agency of sheep grazing—is very suggestive in its bearing on the question of the modifying influence of cultivation and settlement on the native vegetation of any newly occupied district. A somewhat similar condition of things in southern Colorado has lately given rise to actual warfare between sheep and cattle herders, the latter contending that the introduction of sheep and close grazing favors the growth of plants poisonous to cattle.

No. 83. *Peucedanum Newberryi* Watson. AM. NAT., vol. vii, p. 301.

No. 84. *Cymopterus terebinthinus* Torr. & Gray.

No. 85. *Peucedanum macrocarpum* Nutt.

No. 86. *Galium acutissimum* Gray. Dry rocky slopes on the Santa Clara.

——. *Galium multiflorum* Kellogg. Mountains near Cedar City.

No. 87. *Symphoricarpus longiflorus* Gray. Revis. Symph. Jour. Linn. Soc., vol. xiv, p. 12. A slender, intricately branching shrub with small leaves and long slender corolla, white, tinged with pink; 2–3 feet high; abundant among shaded rocks adjoining the Virgen; fl. June.

No. 88. *Symphoricarpus oreophilus* Gray. Revis. Symph. Jour. Linn. Soc., vol. xiv. p. 12. Mountains near Cedar City. July.

No. 89. *Brickellia linifolia* D. C. Eaton. King's Rep., p. 137, t. 15. Cedar City. July.

No. 90. *Brickellia atractyloides* Gray. Proc. Am. Acad., vol. viii, p. 290.

No. 91. *Aster tortifolius* Gray. Proc. Am. Acad., vol. vii. p. 353. A common, large-flowered, pale blue species, growing in rock-crevices near St. George; fl. May.

No. 92. *Erigeron Bellidiastrum* Nutt.

No. 93. *Erigeron stenophyllum*, var. *tetrapleurum* Gray. Very showy with its light blue, copious rayed flowers, growing in crevices of sandstone rocks near St. George; fl. June.

No. 94. *Townsendia strigosa* Nutt. Cedar City. July.

No. 95. *Solidago pumila* Nutt. Cedar City. July.

No. 96. *Acamptopappus sphærocephalus* Gray. Proc. Am. Acad., vol. viii, p. 634; Torr. in Pacif. R. R. Expl., vol. vii, p. 12, t. 6. Common on dry hills near St. George; fl. June.

No. 97. *Aplopappus linearifolius* DC. Sandstone rocks on the Santa Clara. May.

No. 98. *Franseria dumosa* Gray. Abundant near St. George. When in full bloom, in May, the abundant pollen discharged acts as an irritant sternutatory.

——. *Franseria eriocentra* Gray. Proc. Amer. Acad., vol. vii, p. 355. A shrub 3–4 feet high; only late fruiting specimens collected. June.

No. 99. *Hymenoclea Salsola* Torr. & Gray. Pl. Fremont, in Smith's Contrib., vol. vi, p. 14, t. 8.

No. 100. *Monoptilon bellidiforme* Torr. & Gray. Journ. Bost. Soc. Nat. Hist., vol. v, p. 106, t. 13. Only before known from a single Fremontian specimen. St. George; fl. May.

No. 101. *Chænactis macrantha* D. C. Eaton. King's Rep., p. 171, t. 18.

No. 102. *Chænactis stevioides* H. & A. St. George. May.

No. 103. *Chænactis carphoclinia* Gray. Bot. Mex. Bound., p. 94.

No. 104. *Actinolepis lanosa* Gray. Proc. Am. Acad., vol. ix, p. 198, note.

No. 105. *Actinolepis Wallacei* Gray. Proc. Am. Acad., vol. ix, p. 198, note.

No. 106. *Syntrichopappus Fremontii* Torr. Pacif. R. R. Rep., vol. iv, p. 106, t. 15.

No. 107. *Hymenopappus luteus* Nutt. Pine Valley. June.

No. 108. *Thelesperma subsimplicifolium*, var. *scaposum* Gray. Bot. Mex. Bound., p. Pine Valley. June.

No. 109. *Thelesperma subnudum* n. sp., Gray. Proc. Am. Acad., vol. x, p. 72. Low, short-leafy from a much divided perennial base; leaves thickened, rigid, 1–2-ternate, segments short, linear-lanceolate or oblanceolate; peduncles simple, scapiform, about a span high, rays none: achenia smooth, surmounted by an obtuse 4–5 toothed naked corona. Cedar City. July.

No. 110. *Gymnolomia Nuttalli* Gray. Pine Valley. June.

No. 111. *Actinella Richardsonii* Nutt. Var. (?). Pine Valley. June.

No. 112. *Layia glandulosa* H. & A. Bot. Beech., p. 358.

No. 113. *Tessaria borealis* T. & Gr. Pl. Fendl., p. 75; Sitgr. Rep., t. 5.

No. 114. *Psathyrotes annua* Gray. Pl. Wright, part 2, p. 100.

No. 115. *Psathyrotes ramosissima* Gray. Proc. Am. Acad., vol. vii, p. 363, note. Upper and lower surface of the leaves scurfy pubescent; the edges of the leaves and petioles closely set with ciliate jointed hairs, looking under a lens like a string of beads. These swollen glandular portions contain the aromatic resinous oil that gives the peculiar heavy odor to all the species of this genus, being most marked in this particular one.

——. *Psathyrotes Schottii* Gray. Proc. Am. Acad., vol. ix, p. 206. A single speci-

men of this well-marked species was brought by the mail-rider from the lower valley of the Virgen.

No. 116. *Baileya pleniradiata* Harv. & Gray. Pl. Fendl., p 105.

No. 117. *Stylocline micropoides* Gray. Pl. Wright., part 2, p. 81.

No. 118. *Tetradymia spinosa* H. & A.

No. 119. *Tetradymia glabrata* Torr. & Gray. Pacif. R. Rep., vol. ii, p. 122, t. 5. Sevier Valley.

No. 120. *Gaillardia acaulis* n. sp. Gray, Proc. Am. Acad.. vol. x, p. 73. Low, perennial, puberulent; leaves much crowded on the thickened caudex, slightly fleshy, obovate, petiolate with undulate or sub-dentate margins; scape naked, less than a span high, monocephalous; involucre shorter than the disk, outer scales ovate-oblong, inner lanceolate, slenderly acuminate; flowers of the ray and disk yellow; chaff of the receptacle short, ovate-subulate; lobes of the disk-flowers triangular-ovate, somewhat obtuse; scales of the pappus 9, ovate-oblong, pointed.—Gypseous clay hills near Cedar City. July.

Nos. 121, 122. *Gaillardia pinnatifida* Torr.

No. 123. *Senecio Douglasii* DC., var. (?).

No. 124. *Artemisia trifida* Nutt. Valley of the Sevier. July.

No. 125. *Dicoria canescens* Torr. & Gray. Bot. Mex. Bound., p. 86, t. 30. Only a few immature plants obtained, showing it to be an annual, apparently flowering in August or September.

No. 126. *Cnicus undulatus*, var. *canescens* Gray. Proc. Am. Acad., vol. x, p. 42.

No. 127. *Cnicus Arizonicus* Gray. Proc. Am. Acad., vol. x, p. 41. Cedar City. July.

No. 128. *Lygodesmia grandiflora* Torr. & Gray. Gray, Proc. Am. Acad., vol. ix, p. 217, note. Cedar City. July.

No. 129. *Glyptopleura setulosa* Gray. Proc. Am. Acad.. vol. ix, p. 211. Biennial; fl. May. See above, AM. NAT., vol. ix, p. 20.

No. 130. *Malacothrix Coulteri* Gray. Proc. Am. Acad., vol. ix, p. 213, note.

No. 131. *Malacothrix sonchoides* Torr. & Gray. Gray, Proc. Am. Acad., vol. ix, p. 214.

———. *Malacothrix platyphylla* Gray. Proc. Am. Acad., vol. ix, p. 214, note. Lower valley of the Virgen; May.

No. 132. *Stephanomeria Thurberi* Gray, var. *nana*. Pl. Thurber, p. 325.

No. 133. *Lygodesmia exigua* Gray. Proc. Am. Acad., vol. ix, p. 217, note; fl. June.

No. 134. *Stephanomeria exigua* Nutt. Torr. & Gray, flora, vol. 2, p. 473.

No. 135. *Troximon aurantiacum* Hook. Fl. Bor.-Am., vol. i, p. 300, t. 104. Pine valley. June.

No. 136. *Calycoseris Wrightii* Gray. Pl. Wright. Part 2, p. 101, t. 14.

No. 137. *Malacothrix Torreyi* Gray. Proc. Am. Acad., vol. ix, p. 213, note; fl. April.

No. 138. *Rafinesquia Neo-Mexicana* Gray. Pl. Wright, part 2, p. 103; fl. April.

No. 139. *Microseris macrochaeta* Gray. Proc. Am. Acad., vol. ix, p. 211, note.

No. 140. *Microseris linearifolia* Gray. Proc. Am. Acad., vol. ix, p. 211, note.

No. 141. *Perezia microcephala* DC. Dry rocky slopes near St. George; 2–3 feet high fl. June.

No. 142. *Encelia Californica* Nutt., var. (?).

THE INVERTEBRATE CAVE FAUNA OF KENTUCKY AND ADJOINING STATES.

BY A. S. PACKARD, JR.

I. ARANEINA.

In an article on the insects and crustaceans of Mammoth Cave, based on specimens obtained by Messrs. F. W. Putnam and C. Cooke, published in 1871 (AMERICAN NATURALIST, vol. 5), I expressed the hope that thorough zoological explorations of Mammoth Cave would be made by a state commission or by persons acting under the authority of the state. This hope has been fully realized. Since the publication of the "Mammoth Cave and its Inhabitants,"[1] the new geological survey of Kentucky has been instituted, under the charge of Prof. N. S. Shaler, who invited Mr. Putnam and myself to explore the caves of Kentucky under the auspices of the survey. Accordingly, during portions of the months of April and May, 1874, I examined Mammoth Cave and several adjoining, *i. e.*, White's Cave, Dixon Cave, Diamond Cave and Proctor's Cave, in company with Prof. Shaler and Mr. F. G. Sanborn, assistant on the survey, and subsequently Mr. Sanborn explored these and Carter caves. In company with Prof. Shaler, I also made a slight examination of the four Carter caves. Fully appreciating the importance of the subject of cavern life and of comparing the fauna of different caves, Prof. Shaler invited me to visit Wyandotte Cave, and the Bradford caves in Indiana. The Bradford caves I visited in company with Dr. John Sloan, of New Albany, Ind., who had already examined, with much success, many of the small caverns in southern Indiana. His observations on the temperatures of the caverns of his state are of much interest, and will be published in a succeeding paper. The collections made by him and contained in the Museum of Natural History of New Albany were also examined, and he has kindly sent me other material. On my return I examined Weyer's Cave and adjoining Cave of the Fountains near Staunton, Virginia, and discovered about twenty forms, where before none were known to inhabit

[1] By A. S. Packard, Jr. and F. W. Putnam, 8vo. pp. 62. With two plates and cuts. Salem, 1872.

those caves. In the autumn Mr. Putnam made a thorough exploration of Mammoth Cave. These papers are accordingly based on material collected by him, Prof. Shaler, Mr. Sanborn, Mr. Cooke, Dr. Sloan and myself.

Mr. Emerton kindly identified and described the spiders of the caves, and his paper and drawings accompany this article. The Coleoptera have been identified by Dr. LeConte, the Diptera by Baron Osten Sacken, and the only Neuropterous insect found, an immature Psocus, has been figured and identified, so far as it could be, by Dr. Hagen.

Without at this time speaking of the physical aspects of the caves, I may say that the life of the caverns is much more abundant than I had supposed from the accounts given by others. The spiders were found not infrequently in all the caverns mentioned in the notes appended to Mr. Emerton's descriptions. I should say that the spiders were equally abundant in Mammoth and Wyandotte caves, but they were most abundant in Weyer's, where three species occurred. They were next commonest in the Carter caves. These are small caverns, none more than a mile in extent; but it is interesting to observe that in Mammoth and Wyandotte caves respectively, both between five and seven or eight miles in extent, so far as rude measurements show, there was but a single species. The following table shows the distribution of the six species of true cave spiders:

MAMMOTH.	WYANDOTTE	BRADFORD.	CARTER.	WEYER'S.
Anthrobia mammouthia	Linyphia subterranea	?Nesticus Carteri.	Nesticus Carteri.	Nesticus pallidus.
			Linyphia subterranea.	Linyphia Weyeri.
			Linyphia incerta.	Linyphia incerta.

It will be seen that the two largest and consequently most ancient caverns, Mammoth and Wyandotte, and in which the physical environment of the species is most unvarying, have but one species each. The *Anthrobia mammouthia* is only found in Mammoth, and the small caverns, *i. e.*, Diamond and Proctor's, situated about five miles from it. No other species occurred in these smaller caves. The only spider found in Wyandotte Cave was the *Linyphia subterranea*, which also occurred in the Carter caves,

while in the Bradford Cave occurred a Nesticus thought by Mr. Emerton to be identical with *Nesticus Carteri*. The Carter caves and Weyer's caves are small caverns, all perhaps less than half a mile in length, with the exception of Bat Cave which is perhaps over a mile in length; the distances are uncertain, these caverns winding about very irregularly and their length is only estimated by guesswork.

It is in the small caverns of Carter County, Kentucky, and the two Weyer's caves (Weyer's and the adjoining Cave of the Fountains) which are often but a few (less perhaps than a hundred) feet below the surface, that the variation and number of species is greatest. In each set of caves there are three species, to one in Mammoth and Wyandotte caves. The individual variation was the greatest in *Nesticus pallidus*, and, as might be suspected, in the eyes. The degree of variation is indicated in Mr. Emerton's description.

The spiders occurred more abundantly in all the caves than we expected. The individual abundance was greater in the smaller caverns, especially the Weyer's caves, than any others. In the Mammoth Cave the Anthrobia occurred under stones in dry but not the driest places, on the bottom at different points in the cave. Sometimes two or three cocoons would be found under a stone as large as a man's head. The cocoons were orbicular, flattened, an eighth of an inch in diameter, and formed of fine silk, and contained from two to five eggs. They occurred with eggs in which the blastodermic cells were just formed, April 25th. The eggs were few in number and seemed large for so small a spider, being $\frac{25}{1000}$ inch in diameter. The chorion is very thin, and finely speckled. The blastodermic cells seemed very large, the largest measuring nearly $\frac{4}{1000}$ inch in diameter. They were round, not closely packed and showing no indications of being polygonal. They all had a dark, very distinct nucleus. I was unable to trace the development of the young, and ascertain if the embryos are provided with rudimentary eyes. Two young *Anthrobiæ* hatched out May 3d in my room. The whole body, including the legs is snow white, with the legs much shorter than in the adult. The adult in life is white, tinged with a very faint flesh color, with the abdomen reddish, in some specimens the abdomen has beneath several large transverse dusky bands. The *Linyphia subterranea*, as observed living in Wyandotte Cave, is pale pinkish horn brown on the thorax and legs, while the abdomen is dull honey-yellow.

What constitutes the food of these diminutive, weak, sedentary spiders, I cannot conjecture, unless it be certain minute delicate mites or young Poduræ. They spin no web, though some of the spiders in Weyer's Cave (Cave of the Fountains) do spin a weak, irregular web, consisting of a few threads. The Sciaræ and Chironomus are too large and bulky to be captured by them. The probable insufficiency of food as well as light, may account for their small size and feeble reproductive powers. The individuals were far less numerous than those of the Acanthocheir and Chelifers.

The distribution of Cave Araneina in the middle states, is paralleled by that of the other insects, as we shall see in subsequent papers. The other Arachnidans follow much the same law. So with the Myriopods. The *Spirostrephon* (Scoterpes) *cavernarum*, of Wyandotte Cave occurs abundantly in the Carter caves, but not in Mammoth Cave, which is so much nearer Wyandotte Cave. The common myriopod of Weyer's Cave, on the other hand, is closely allied to *Spirostrephon Copei*, but much less hairy.

I may here anticipate a fact which I shall bring out more fully in a subsequent paper and which has an important bearing on the derivative theory. I found in the Carter caves several specimens of *S. cavernarum* which were reddish-brown, and had apparently larger eyes than the normal white examples characteristic of the Carter and Wyandotte caves. I regard it as extremely probable that this reddish race has not been established long enough in the cavern to lose its original brown color. We here see, in fact, a cave species in process of formation, and I regard this as one of several facts which I hope to offer in subsequent papers, tending to prove that nearly all the cave animals are modified forms living at the present day out of doors. In all the caves examined, except Mammoth and Wyandotte, living Pulmonate mollusks occurred. The large dead snail shells I found on the banks of the river Styx in Mammoth Cave, must have been carried in dead by floods from the Green River or through fissures from above.

Every vegetable was carefully preserved. The common plant found in Mammoth Cave has been identified by Prof. Farlow as the old *Byssus aurantiaca*, now known under the name of *Ozonium auricomum* Link. Prof. Farlow, who kindly identified the cave plants, says that it is "found in caves on wood in Great Britain, Germany, etc., and has been found in Michigan and elsewhere by Schweinitz. As far as I know it is simply the mycelium of some

unknown fungus." A young Peziza occurred in Weyer's Cave, it was not in fruit, was colorless, and impossible to determine specifically. A colorless Agaric also occurred in Weyer's Cave.

The temperature of Weyer's Cave on May 18th, was 55°–56° Fahr. for both water and air; that of Zwingle's and Bat Cave (Carter caves) was ascertained by Prof. Shaler to be 48° for the water. Dr. Sloan ascertained the temperature of the brook in Bradford Cave to be 55° on May 9th. The temperature of Mammoth Cave is 59° the year around, according to Prof. B. Silliman. Mr. H. W. Conrad, proprietor of Wyandotte Cave, informs me that the temperature of Wyandotte Cave varies from 54° to 57° F.; that of Little Wyandotte Cave in April is 50°.

NOTES ON SPIDERS FROM CAVES IN KENTUCKY, VIRGINIA AND INDIANA.

BY J. H. EMERTON.

The collection of cave spiders contained about one hundred specimens of eleven species. Two species were found only about the mouths of caves. These are *Theridion vulgare* Hentz, a spider found all over the country in shady places, and a large species of Meta, which has been found in similar situations in Massachusetts and New Hampshire, and resembles *Epeira fusca* Blackwall. One young spider allied to Tegenaria was taken in Fountain Cave, Virginia, and four specimens of a species of the same family were found in small caves in Carter county, Kentucky; all were immature except one female, and none showed any subterranean characters. The remaining six species, all belonging to the *Theridiidæ*, were found in considerable numbers in the larger caves where there is little or no light and the climate is little affected by outside changes. One species of Linyphia from Weyer's Cave, Virginia, has the eyes of the normal size and number, and the colors and markings of some specimens are as bright as on spiders of the same family living in cellars or shady woods. The other five species are all pale in color and show some unusual condition of the eyes, three species having the front middle pair very small, one having all the eyes small and colorless,

with the front middle pair wanting in the males and some females, and one species being entirely without eyes. Following are descriptions of the last six species.

Nesticus pallidus n. sp.—Plate 1, Figs. 22-27. Cephalothorax and legs pale orange-brown, abdomen yellowish-white with brown hairs. Length of female 3.5 mm. Cephalothorax 1.5 mm. long and nearly as broad, little elevated in front; three lines of hairs from the eyes to the dorsal pit. Front middle eyes black and half as large as the others, nearly touching each other. Rear middle eyes separated from each other by their diameter and from the front middle eyes by half that distance; lateral eyes in pairs separated from the middle eyes by half their diameter. Mandibles half as long as the cephalothorax. Maxillæ and labium short and wide. Palpal claw long and slender with six teeth along the middle. Legs 1, 4, 2, 3. 1st pair 10 mm., 2d 8.25, 3d 8.15, 4th 9.6, thinly covered with long hairs and without spines. Tarsal claws long and slender, the lower with two teeth, the upper with 9 or 10, Epigynum fig. 27; the sacs showing through the skin in some specimens. The only male taken had not finished moulting and was much distorted by the alcohol. The palpus which had cast its skin is shown in fig. 26, the penis is raised from its natural position, which is in a groove passing spirally round the end of the palpal organ to a fleshy conductor. A long process with two teeth at the end branches from the base of the tarsus.

Fountain Cave, next to Weyer's, Virginia, among stalactites where there was no daylight. Several loose cocoons were found, one containing thirty or forty young just hatched (Packard).

Nesticus Carteri n. sp.—Plate I, Fig. 28. Cephalothorax and legs light yellow, hairs shorter than in *N. pallidus*. Abdomen in some specimens with indistinct gray markings. Eyes smaller and farther separated from each other than in *N. pallidus*. Epigynum fig. 28. This species is otherwise much like *N. pallidus*. Bat Cave, Zwingle's Cave, Carter Co., Ky. (Packard). A cocoon collected by Mr. Packard, from Bradford Cave, Ind., contains young, which had passed their second moult, probably of this species.

Linyphia subterranea n. sp.—Plate I, Figs. 29-31. Cephalothorax and legs yellowish-brown, in some specimens reddish. Abdomen white with brown hairs, in two specimens from Zwingle's Cave gray with white spots. Eyes 8, fig. 30, white surrounded by a dark border, in one specimen colorless without dark borders. Front middle eyes very small and in the two dark specimens from Zwingle's Cave obscured by dark markings on the head. Mandibles with seven teeth in front of the claw grooves. Legs short 1, 4, 2, 3, spines on patella and tibia. Under claw of tarsus with two teeth, the upper claws with eight or nine. No claw on palpi. Epigynum external, as long as the maxillæ, extending backward along the under side of the abdomen (fig. 29-31) or when the abdomen is distended projecting out from it at a right angle.

Under stones in Carter and Wyandotte caves (Packard).

Linyphia Weyeri.—Plate I. Figs. 7-12. Cephalothorax and legs yellow-brown, abdomen from dark gray to white. Length of ♀ 2.25 mm. Cephalothorax wide and but little elevated in front in either sex. Front middle eyes near each other on a black spot, rear middle eyes separated by their diameter and by the same distance from the front middle eyes, lateral eyes in pairs, each pair surrounded by a black area and distant twice its width from the middle eyes. Mandibles long, spreading apart at the tips and inclined backward toward the maxillæ, beyond the ends of which they extend a third of their length in the female and farther in the male; 5 long teeth in front of the claw groove. No palpal claw. Legs 1, 4, 2, 3, first pair 4 mm. long in ♀ and 4.4 mm. in ♂, with two spines on femur, one on patella and two on tibia. Under claw of tarsus with one tooth, upper claws with nine or ten teeth. Epigynum with an oval opening behind, twice as wide as long, in front of which is a short, flexible appendage, fig. 11. Palpus of male, figs. 9 and 10. The tarsal process is a small hook on the upper side, the penis is long, and passes one and a half times round the palpal organ, supported through nearly its whole length by a wide thin conductor ending in a hard tooth. Under the end of the penis is a soft brush-like appendage, and beside it two hard processes.

Weyer's Cave, Virginia, in darkness, but not far from the entrance (Packard).

Linyphia incerta n. sp.—Plate I. Figs. 13–21. Length 2 mm. Cephalothorax and legs orange-brown, abdomen white with short, fine, brown hairs. Cephalothorax 1 mm. long and two-thirds as wide; in the male elevated in front, fig. 20, and furnished with longer hairs than in the female. Eyes small and colorless, and separated far from each other, figs. 18 and 21; the front middle pair are very small, hardly larger than the circles around the bases of the hair by which they are surrounded, and only distinguished from them by wanting the dark rim which surrounds the hair circles. In 5 females from Fountain Cave all the eyes are present, fig. 18; in one female one of the front middle eyes is wanting. In 3 males from the same cave both front middle eyes are wanting, as in fig. 21; in one male one only of the front middle pair is wanting. In 4 females and 1 male from Bat Cave, Carter Co., Ky., the front middle eyes are wanting. Mandibles long and spreading at the tips, inclined backward toward the maxillæ, seven teeth in front of the claw groove, which are longer in the males. No palpal claws. Legs 1, 4, 2, 3, longest 4.75 mm. Tarsal claws short and slender, under claw with one tooth, upper claws with 7 or 8 teeth. Spines on patella and tibia. Epigynum with a small oval opening behind with dark brown border. Palpus of ♂, fig. 17, having a sharply-curved process at the base of the tarsus. The penis is supported by a stout conductor nearly to its end where it passes a soft brush-like appendage.

Fountain Cave, Virginia, among stalactites in company with *Nesticus pallidus* (Packard), also in Bat Cave, Carter Co., Ky. (Shaler & Packard).

Anthrobia mammouthia. Plate I, Figs. 1–6. In 1844, Tellkampf described and figured roughly in Wiegmann's Archiv fur Naturgeschichte, several arthropods from the Mammoth Cave, among them an eyeless spider, which he referred with doubt to the Mygalidæ, apparently because he saw only 4 spinnerets. The eyeless spiders found by Dr. Packard in the Mammoth Cave in 1874 agree generally with Tellkampf's description, and his figure 13 represents quite well the outline of a specimen, flattened by pressure between two glasses. No other eyeless spider was found, and no other which could be identified with Tellkampf's description. There seems, therefore, little doubt that these are spiders of the same species as those described by Tellkampf. Adults, 1.5 mm. long, pale brownish-yellow, abdomen almost white with brown hairs, ends of palpi, palpal organs and epigynum reddish-brown. Cephalothorax with scattered hairs in front. No eyes. Mandibles with 4 long teeth in front of the claw groove. Maxillæ short and wide. Sternum wide and hairy. Legs 1, 4, 2, 3, longest about 2.5 mm., hairy, with spines on patella and tibia. Under tarsal claw with one tooth, the upper claws with 6 or more short teeth. No palpal claw. Palpus of ♂, fig. 3, with a long process on the outside of the tibia ending in a sharp hook. The tarsal process forms a small thin hook. Palpal organ very simple, the penis very short and accompanied by a soft, thin appendage. Spinnerets short, Hypopygium ½ the length of the first pair.

Mammoth Cave and Proctor's and Diamond caves, under stones (Sanborn & Packard). Small flat cocoons were found with some specimens, containing small numbers of eggs which were unusually large in proportion to the size of the spider.

[In this connection it may be of interest to learn the opinion of Dr. T. Thorell, the accomplished arachnologist of Upsala. Upon receiving a specimen of *Anthrobia mammouthia*, which I sent him, he writes me that "the Anthrobia if it really is the true *A. mammouthia* Tellkampf, scarcely differs from the genus Erigone by anything more than the want of eyes; it may, however, be added as a peculiarity, that the three long and slender tarsal claws are quite smooth, neither dentated nor pectinated. The species belong most certainly to the family *Theridiidæ*."

On the other hand on the receipt of a specimen of the same species of spider and from the same cave (Mammoth) as that from which the specimen was taken which was sent Dr. Thorell, M. Simon of Paris writes me that "the Anthrobia is not allied to *Mygalidæ*, as was supposed from the imperfect description of Tellkampf, but to our *Dysderidæ*, and the genus Leptoneta, only it is blind."—A. S. P.]

EXPLANATION OF PLATE I.

1. Anthrobia mammouthia ♀.
2. " " ♀, under side.
3. " " palpus of ♂.
4. " " ♀ side view.
5. " " front of head and mandibles.
6. " " foot of first pair.
7. Linyphia Weyeri ♂.
8. " " maxillæ and mandibles of ♂.
9–10. " " palpus of ♂.
11. " " epigynnm.
12. " " foot.
13. Linyphia incerta ♂.
14. " " ♀ maxillæ.
15–16. " " palpus of ♂.
17. " " epigynum.
18. " " eyes of ♀ from Fountain Cave.
19. " " foot.
20. " " ♂ side view.
21. " " ♂ front of head and mandibles.
22. Nesticus pallidus ♀.
23. " " ♀ under side.
24. " " ♀ side view.
25. " " ♀ foot.
26. " " palpus of ♂.
27. " " epigynum.
28. Nesticus Carteri ♀ epigynnm.
29. Linyphia subterranea ♀ under side.
30. " " ♀ front of head and mandibles.
31. " " ♀ side view.

LIFE HISTORIES OF THE MOLLUSCA.

BY A. S. PACKARD, JR.

I. LAMELLIBRANCHS.

HAVING gone thus far along the track leading from the moners to man, we come to where the road branches in several directions. The path from the Protozoa to the sponges, from the sponges to the polypes, and from the polypes to the Ctenophoræ, and through them to the Echinoderms, though at times devious and readily lost, yet in the retrospect is more easily followed than those lying before us. In fact there is no single track leading directly from the lowest to the highest animals. We have to follow distinct lines of development, and, after toiling up one ascent, find that it ends abruptly, without bringing us very near the goal. We then have to retrace our steps, return to the old fork in the road and essay a new path. For example, following up the line of mollusca, we come to the cuttlefishes with their well developed eyes and circulatory apparatus, nearly as complicated as those of fishes. If we follow the ascidian line of development, we trace immediately in their larval condition a *chorda dorsalis* and a relation of rudimentary organs which bear a striking analogy to those of Amphioxus, the lowest vertebrate. Again, in studying the Brachiopods, we follow a line of life which leads us to forms such as the Lingula which combines Annelid characters with remarkable features of its own. If after traversing these paths we take up the long and devious route which leads from the Rotifers through the non-segmented worms up to the leeches and Annelides, to the Crustacea and Insects, we shall then reach animals which in many respects are only inferior to the vertebrates, and in complexity of organization, in their morphology and in their psychological endowments, are on the whole, superior to any other invertebrates.

What is this initial point from which these lines diverge? It is a larval form having a bilateral, cylindrical body, sometimes annulated, divided into a preoral and postoral region, *i. e.*, a head and hind body, with a ciliated crown, often a whip-lash or tuft of bristles, with a mouth, a usually curved alimentary cavity, and anus opening often near the mouth. This stage is seen in the

young Echinoderm, such as the Auricularia or Bipinnaria; or in the Veliger state of the young mollusk; in the young worm, whether the "Actinotrocha" of the Sipunculus, or "Tornaria" of Balanoglossus, or "Mesotrocha" of a higher annelid, or even in the young Rotifers. For such a form the term *Cephalula* may be proposed in allusion to the fact that a cephalic region is indicated in this state, the Gastrula being a simple sac with the head end not differentiated from the opposite extremity. Let the reader compare the gastrula of the sponge (Fig. 49) with the Cephalula of the Trochus (Fig. 138, B) and he will detect the difference between the two stages. This stage is thus named simply to give emphasis to the fact that it is a form common at one stage in their life-history to several entirely different classes of animals, radiate, articulate and molluscan, independently of any theoretical considerations. I will only say that the Cephalula bears an analogous relation to these classes, as the Planula to the Radiates, the Nauplius to the Crustaceans, or the Leptus to the Insects.

We shall see in our future studies of the life-histories of the different classes of invertebrate animals, how often this Cephalula, with its ciliated crown, recurs.

No one has ever given a thoroughly satisfactory definition of the type of Mollusca, and we shall certainly not attempt one here. It may be said, however, that they are in their early stages, and in nearly all (except the Gastropoda, in which the visceral or abdominal end is asymmetrical), in adult life bisymmetrical animals bearing usually an external or internal shell (sometimes the shell is larval and deciduous), with the under lip converted into an organ of locomotion, the large fleshy foot. The nervous system consists of three pairs of ganglia usually surrounding the œsophagus, sending nerve-threads in irregular directions to the different organs.

The Mollusca usually have a well developed heart, more so than in the Crustacea and Insects, situated dorsally and consisting usually of a ventricle and two auricles. The respiratory organs depend or project from the mantle or tegument, and are permeated by a net-work of blood-vessels. A large number have an "odontophore" or "lingual ribbon, a band of teeth rolled up in the mouth. The mollusks are neither radiate nor segmented as in the Articulates or Vertebrates, though certain larvæ are indistinctly annulate as in that of Chiton.

For a further discussion of the characters of the mollusks as compared with the worms the reader is referred to Prof. Morse's memoir "On the Systematic Position of the Brachiopoda."[1]

The following tabular view of the mollusks is copied from Gegenbaur's "Principles of Comparative Anatomy." For further information the reader is referred to Woodward's "Manual of the Mollusca."

MOLLUSCA.

I. LAMELLIBRANCHIATA.
  1. *Asiphonia* (Ostræa, Anomia, Pecten, Mytilus, Arca, Unio).
  2. *Siphoniata* (Chama, Cardium, Cyclas, Venus, Tellina, Mactra, Solen, Pholas, Teredo).

II. CEPHALOPHORA.
  1. *Scaphopoda* (Dentalium).
  2. *Pteropoda.*
    Thecosomata (Hyalea, Cleodora, Chreseis, Cymbulea, Tiedemannia).
    Gymnosomata (Pneumodermon, Clio).
  3. *Gastropoda.*
    Heteropoda (Atlanta, Carinaria).
    Opisthobranchiata (Bulla, Aplysia, Doris, Glaucus, Æolis).
    Prosobranchiata.
      Cyclobranchiata (Patella, Chiton).
      Ctenobranchiata (Paludina, Neritina, Buccinum, Purpura, Murex, Fusus, Conus, Oliva, Strombus, Haliotis).
  4. *Pulmonata* (Lymnæus, Physa, Planorbis, Helix, Bulimus, Limax).

III. CEPHALOPODA.
  1. *Tetrabranchiata* (Nautilus).
  2. *Dibranchiata.*
    Decapoda (Spirula, Sepia, Loligo).
    Octopoda (Octopus, Argonauta).

Development of the Lamellibranchs. It is only within a comparatively few years that we have learned anything of the mode of growth of our commonest bivalve mollusks. To this day the life history of the common clam or quahaug is a mystery. The early stages of the oyster are only partially known. We know much less about the early stages of the common sea mussel; while the history of the fresh-water mussel (Unio) sketched roughly in 1831 by Carus, is still fragmentary. For the first definite knowledge of the metamorphoses of the Lamellibranchs, we are indebted to the distinguished Swedish observer Lovén, who gave between the years 1844 and 1849, a series of sketches more or less complete of

[1] Proceedings of the Boston Society of Natural History, Vol. xv, 1873, 8vo. pp. 60.

a number of marine forms. To him and to Sars, the famous Norwegian zoologist, who made the first sketch of the metamorphoses of the Gastropods, we are indebted for our earliest and most valuable facts in the life-history of the mollusks. Before this, some larval mollusks were regarded as infusoria by Ehrenberg.

Of the mode of development of the oyster, the lowest lamellibranch, the first information was supplied by Lacaze-Duthiers (1854–5), supplemented by the recent (1874) observations of Salensky. While some lamellibranchs, such as the Unio, are bisexual, the oyster is hermaphroditic. The eggs, which are yellow, after leaving the ovary are retained among the gills. A single oyster may lay 2,000,000 eggs. The spawning time of the oyster in Europe is from June to September. During their development the eggs are enclosed in a creamy slime, growing darker as the "sprat" (the term applied to the young oysters) develops.

The course of development is thus: after the segmentation of the yolk (morula stage), the embryo divides into a clear peripheral layer (ectoderm), and an opaque inner layer containing the yolk and representing the inner germinal layer (endoderm). A few filaments or large cilia arise on what is to form the velum or the future head. The shell then begins to appear at what is destined to be the posterior end of the germ, and before the digestive cavity arises. At this stage the two-layered germ is said by Salensky to represent the planula of the sponge. The digestive cavity is next formed (gastrula stage), and the anus appears just behind the mouth, the alimentary canal being bent at right angles. Meanwhile the shell has grown enough to cover half the embryo, which is now in the "Veliger" stage, the "velum" being composed of two ciliated lobes in front of the mouth-opening, and comparable with that of the gastropod larvæ. The young oyster, as figured by Salensky, is directly comparable with the Veliger of the Cardium (Fig. 121).

We have, then, three stages of growth in the oyster, (1) the morula, (2) the gastrula (with the digestive cavity as yet undeveloped and, (3) the veliger with an alimentary canal and a head and hind body (cephalula). This is an epitome of the mode of development of most of the lamellibranchiate mollusks whose embryology is known. Soon the shell covers the entire larva, only the ciliated velum projecting out of an anterior end from between the shells. In this stage the larval oyster leaves the mother and

swims around in the water, the cilia of the velum keeping up a lively rotary motion. In this state Lacaze-Duthiers observed it for forty-three days, without any striking change in form, except that the velum increased in size, and the auditory vesicle appeared, containing several otoliths, which kept up a rapid motion. But still the gills and heart were wanting. Of its further history we know but little, except that it becomes fastened to some rock and is incapable of motion. The oyster is said by the appearance of its shell, to be three years in attaining its full growth, but this statement needs confirmation.

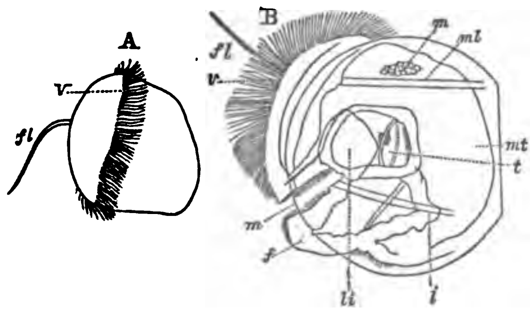
The most complete life history of a bivalve mollusk is that of Cardium (*C. pygmæum*), the cockle shell, as described by Lovén. The egg of this shell is spherical, the yolk being surrounded by a layer of white protoplasm, much as in the eggs of vertebrates. The process of fertilization was observed by Lovén, who saw the spermatic particles of the usual form, *i.e.* with a head and long tail, to the number of a dozen penetrating through the envelopes of the egg out toward the yolk. Following the morula condition the embryo consists of two layers, an outer peripheral clear mass like the "white" of an egg (ectoderm), and a central dark mass, regarded by later observers as equivalent to the inner germinal layer. The embryo now becomes ciliated on its upper surface and already rotates in the shell. On one side of the oval embryo is an opening or fissure,[1] on the edges of which arise two tubercles which eventually become the two "sails" of the velum. This probably represents the gastrula stage, and the embryo already shows a tendency to become bilateral. The next step is the differentiation of the body into head and hind body, *i.e.* an oral (cephalic) and postoral region. Out of the middle of the head grows a single very large cilium, like the whip-lash of the Flagellata, the so-called flagellum (Fig. 121 A, *fl*; *v*, velum). The shell (Fig. 121 B, *sh*) and mantle (*mt*; *ml*, muscle) now begin to form. From the inner yolk-mass are developed the stomach, the two liver lobes (*li*) on each side of the stomach (*t*), and the intes-

[1] This primitive opening, the mouth, appears both in Cardium and Crenella, according to Lovén's figures and descriptions, long before the shell begins to form. It is thus not a secondary formation, as Salensky insists, but a primary invagination of the ectoderm. The embryo is therefore properly a gastrula. It will be remembered that in the oyster on the contrary the shell begins to form before the mouth-opening appears. The young oyster at the stage immediately succeeding the morula is, then, a planula; the Cardium and Crenella, a gastrula. This exception does not warrant us in denying a gastrula state to the Lamellibranchs as a class, as Salensky does.

tine (*i*). The mouth (*m*), which is richly ciliated, lies behind the velum, the alimentary canal is bent nearly at right angles and the anus opens behind and near the mouth. The velum (Fig. 121, *v*) really constitutes the upper lip, while a tongue-like projection (Fig. 121, B *f*) behind the mouth is the under lip, and is destined to form the large impaired "foot," so characteristic of the mollusks.

In a stage previous to this, when the shell only partially covers the animal, the veliger may be compared with the veliger of Trochus (Fig. 138, B) and a remarkable resemblance be traced, the velum, the bent alimentary canal and the foot being almost identical. The shell arises as a cup-shaped organ in both bivalves and univalves, but the hinge and separate valves are indicated very early in the lamellibranchs. The earliest phase of the veliger stage

Fig. 121.



Development of Cardium. After Lovén.

(cephalula) indicated at Fig. 121 A, in which a cephalic and abdominal region is demarked, may be compared with profit by the reader with the embryo infusorian with its cup-shaped body and its crown of cilia, or with the larval Polyzoan or even the larval Brachiopod to be hereafter figured. At the stage represented by Fig. 121, B, the stomach is divided into an anterior and posterior (pyloric) portion. The liver forms on each side of the stomach an oval fold, and communicates by a large opening with its cavity; while the intestine elongates and makes more of a bend. The organ of hearing then arises, and behind it the provisional eyes, each appearing as a vesicle with dark pigment corpuscles arranged around a refractive body. The nerve ganglion (*m*) appears above the stomach. The two ciliated gill-lobes now appear, and the number of lobes increases gradually to three or

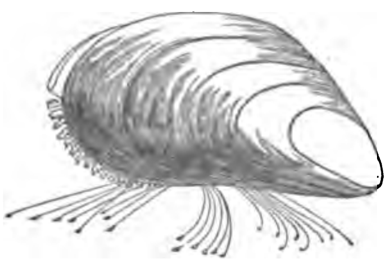
four. The foot grows larger, and the organ of Bojanus, or kidney, becomes visible. The shell now hardens; the mouth advances, the velum is withdrawn from the under side to the anterior end of the shell. In this condition the veliger remains for a long time, its long flagellum still attached, and used in swimming even after the foot has become a creeping organ. Latest of all appears the heart, with the blood-vessels.

Upon throwing off the veliger condition, the velum contracts, splits up and Lovén thinks it becomes reduced to the two pairs of palpi, which are situated on each side of the mouth of the mature lamellibranch. The provisional eyes disappear, and the eyes of the adult arise on the edge of the mantle.

The mode of development of *Crenella marmorata* is nearly identical with that of Cardium. The Crenella is diœcious, the females being known by their reddish ovaries, the males by their white sexual glands. In this genus, however, there is no egg-capsule, and no "white" enveloping the yolk.

All that we know of the development of the common muscle (*Mytilus edulis*, Fig. 122, after Morse) is from studies made by Lacaze-Duthiers on the shores of the Mediterranean. The larval forms were not discovered. The young about $\frac{1}{2}^{mm}$ in length were found swimming at ebb tide on the surface of the water. The shell at this stage is like a Crenella, and there are four long gill lobes, which arise from the outer lamella of the inner gill.

Fig. 122.



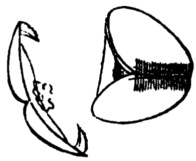
Common Mussel.

The fresh water bivalves pass through entirely different phases of development from the marine forms. The eggs of Cyclas have no shell, no "white" and no yolk skin; they are few in number, from one to six existing in unequal degrees of development in broad cavities filled with a nutritive fluid, and hanging free from the base of the inner gill. The velum is either absent or very slightly developed, and the shell begins to develop at two widely separated initial points on the mantle, according to Leydig.

The fresh water mussels (Unio, Fig. 123, after Morse, and Anodonta) represent another mode of development. In their embryo

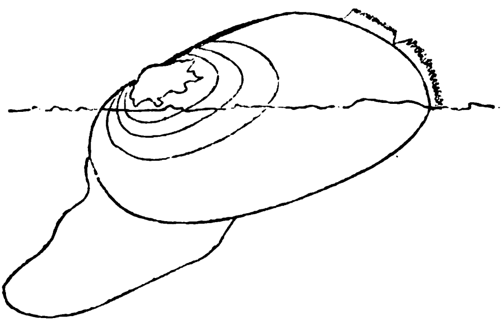
the velum is wanting or exists in a very rudimentary state. The mantle and shell are developed very early. They live within the parent fastened to each other by their byssus. The shell (Fig. 124) differs remarkably from that of the adult, being broader than long, triangular, the apex or outer edge of the shell hooked, while from different points within project a few large, long spines. So different are these young from the parent that they were supposed to be parasites and were described under the name of *Glochidium parasiticum*. They are found in the parent mussel during July and August. The eggs have a shell, "white," and yolk skin and a micropyle. The embryo rotates,

Fig. 124.



Young Unio.

Fig. 123.



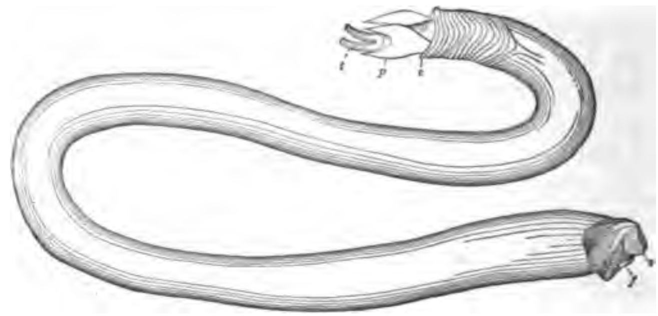
Unio moving through the sand with the siphons expanded.

and remains a month in the egg. When hatched, great numbers still remain among the gills in a mass of slime, and during this time the shell thickens, grows rounder and somewhat longer.

The history of the ship worm (Fig. 125, *Teredo navalis* Linn.) is one of great interest both from a practical and scientific point of view. To the eminent French naturalist, Quatrefages, we are indebted for its life history. Its general development up to the time of the larval stage is much like that of the oyster. The egg has no shell. After fertilization it undergoes total segmentation (Fig. 126, A). The two germinal layers appear as usual, the velum arises much as in the embryo oyster, there being no lash, as in the Cardium, but scattered cilia. Swimming about in this state the embryo would be mistaken for an infusorian. In forty-eight hours after life begins, the cilia begin to disappear and the germ

sinks to the bottom. A deep fissure now separates the germ into halves; meanwhile the mantle and shell have grown, and when

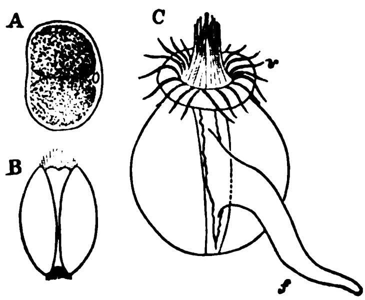
Fig. 125.



The Ship Worm.[1] After Verrill.

five days and a half old the germ appears as in Fig. 126, B, the shell almost covering the larva. Soon after this the velum becomes larger, and then decreases, the gills arise, the auditory sacs develop, the foot grows, though not reaching to the edge of the shell, and the larva can still swim about free in the water. When of the size of a grain of millet, it becomes spherical, as in Fig. 126, C, brown and opaque. The long and slender foot projects far out of the shell, and the velum assumes the form of a swollen ring on which is a double crown of cilia.

Fig. 126.



Development of the Ship Worm.

The ears and eyes develop more, and the animal alternately swims with its velum, or walks by means of the foot. At this stage Quatrefages thinks it seeks the piles of wharves and floating wood in which it bores and completes its metamorphosis. The further changes must be very great before it assumes the adult form of the ship worm with its long body, but these stages have not been observed. Keferstein, however, says that Vrolik saw in July the

[1] Fig. 125, *c*, collar; *p*, pallets; *t*, siphonal tubes; *s*, shell; *f*, foot. After Verrill. Report U. S. Fish Commissioner. Fig. 126, *v*, velum; *f*, foot. After Quatrefages.

larvæ swimming about on the coast of Holland, and some by the middle of the month had bored into the wood and attained the adult Teredo form, though still very small, while others in September still retained their larval, veliger shape. It requires about three weeks for them to complete their metamorphosis. Verrill states that the *Teredo navalis* on the coast of New England "produces its young in May, and probably through the greater part or all of the summer." Quatrefages says that the Teredos die during the winter succeeding their birth.

Keferstein tells us that some lamellibranchs attain their growth in one year. The fresh water mussels (Unio and Anodonta) are thought to live from ten to twelve years, while *Tridacna gigantea* probably lives from sixty years to a century.

The time of spawning usually takes place in summer. The edible mussel (*Mytilus edulis*) and different species of Venus are found with eggs and embryos among the gills from March till May, on the coast of Holland and France, while Pholas and Pandora and most other genera breed from July until September. On the Sicilian coast, according to Poli, Mya and Solen breed early in spring; Pholas, Chama, Venus, Donax, Anomia, Tellina and Mactra in summer; Mytilus edulis from October to December.

We have seen that the Lamellibranchs pass through a true veliger stage, and we shall soon see that their larval forms are directly comparable with the veliger state of most Cephalophora. In after life the "head" of the bivalve, *i.e.* the oral and preoral part of the body, which was fully half as large as the body in the veliger, diminishes greatly in size and importance, becoming finally merged with the postoral region and represented simply by the palpi and foot, the mouth-opening being situated at or near the extremity of the body, so that the old term Acephala well indicates the want of a cephalic region as compared with the large and well developed head of the snails (Cephalophora) and cuttle-fishes (Cephalopoda).

The summary of changes is usually as follows:

1. Egg fertilized by tailed spermatic particles.
2. Morula.
3. Gastrula. (Observed in a very few cases.)
4. Veliger (Cephalula). In Unio and Cyclas wholly or mostly suppressed.
5. Adult Lamellibranch.

LITERATURE.

J. E. Carus. Entwicklung von Unio und Anodonta. (Nova Acta Phys. Med. Leopold. 1831).

S. Lovén. Development of Marine Lamellibranchs. (Ofversigt af Kong. Vetensk. Akad. 1844–1849. Wiegmann's Archiv, 1849. See also Keferstein's abstract in Bronn's Classen und Ordnungen der Thierreichs, vol. iii.)

A. de Quatrefages. Anatomie et Embryologie de la Teredo. (Annales des Sciences Nat. 1848–50.)

Lacaze-Duthiers. Development of various Lamellibranchs. (Annales des Sc. Nat. 1854, 1855).

O. Schmidt. Entwickelung von Cyclas. (Müller's Archiv, 1854).

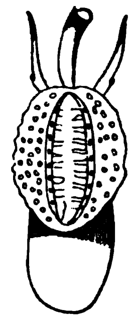
F. Leydig. Cyclas; Anatomie und Entwickelung. (Müller's Archiv, 1855).

W. Salensky. Bemerkungen über Hæckel's Gastræa-Theorie, with three drawings of the embryo oyster and very brief description. (Wiegmann's Archiv, 1874).

II. THE CEPHALOPHORA.

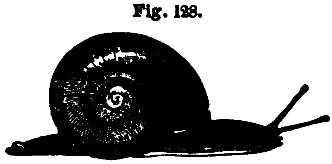
The Cephalophora include not only the Gastropods (snails and whelks) but more aberrant forms such as the swimming Pteropods

Fig. 127.



Trivia, a Gastropod. After Stearns.

Fig. 128.

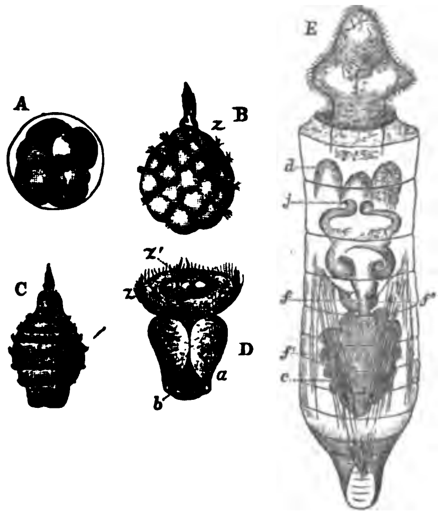


Helix in its natural position, creeping.

and the Dentalium, etc. The term indicates the presence in the adult of a well formed head, as distinguished from the acephalous clams. Not only is there a head, but the eyes are restricted to the most anterior part of the preoral region, being, as in the snail, borne on extensile tentacles, whereas in the bivalves, such as the pecten, the eyes are scattered on the edge of the mantle along the entire body. The adult animal is not symmetrical, the mantle containing the viscera being thrown on one side. The foot is greatly enlarged, forming the entire under side of the animal, as in the snail (Fig. 128). The shell is usually external, spiral and asymmetrical, or cup-shaped.

The tooth shell, or Dentalium, is the lowest of its class, and its life history is one of much interest. For the following facts we are indebted to the memoir of Lacaze-Duthiers. The sexes are distinct. It breeds from the beginning of August until the middle of September. After fertilization by the spermatic particles, which Lacaze-Duthiers saw penetrating into the egg, the egg undergoes complete segmentation (A). At the end of this time the embryo swims about by means of tufts of fine cilia (Fig. 129, B), and a pencil of large cilia in front. It then lengthens and is provided with seven bands of cilia, and the larva is remarkably worm-like

Fig. 129.



Development of Dentalium.

(C). When two days old the mantle secretes a small shell (a) at the end of the body. The ciliated bands now approach and form a swollen ring, or ciliated crown, the velum, as in fig. 129, D, z. At this time the shell is median, unpaired and situated on the back of the larva. The lobes of the foot next arise. Fig. 129, E, represents the young Dentalium, after leaving the larval state, and when thirty-five days old. The three-lobed foot protrudes from the shell now enclosing the animal, the rudimentary tentacles (E, d) are visible, as well as the subœsophageal nerve-ganglia (E, j) and the digestive canal (E, f, f'') and liver (f'). After this, the change into the mature form is slight.

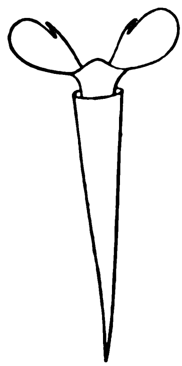
The winged sea-snails (Pteropods) are beautiful creatures found floating on the high seas. With their large, ciliated velum and rudimentary foot they represent the Veliger or larval condition of the Gastropods. There is scarcely a more strikingly beautiful and strange object in nature than the Spirialis with its large heavily ciliated velum, which may be caught in our harbors with the towing net and compared with the young veligerous gastropods often captured in the same net.

The egg of Cavolinia undergoes total segmentation, and before the large yolk-spheres are absorbed, the spherical embryo swims about like a larval infusorian with a crown of cilia. It may now be called a Trochosphere. Soon the larva assumes a conical form

Fig. 130.

Pteropod larva.

Fig. 131.



Styliola vitrea.

Fig. 132.

Æolis, a Nudibranch.

Fig. 133.

Larval Nudibranch.

and subsequently the velum greatly expands. Afterwards the Cavolinia, with its projecting foot, assumes a form much like the veliger of Trochus (Fig. 140, B). Fig. 130 (after Gegenbaur), represents a singular Pteropod veliger after the velum has disappeared, consisting of three distinct ciliated segments, like a worm. Fig. 131, after Verrill, represents an adult Pteropod, *Styliola vitrea*, enlarged three times, with the wings of the velum.

Bulla, Æolis and Doris, represent the Opisthobranchiate or naked mollusks, which either, as in the two latter genera, have no shell, with the gills arranged singly or in tufts on the back, or possess a white shell, as in Bulla, the bubble shell. Fig. 132 (from Verrill's Report, represents *Æolis*). Fig. 133[1] (after Schultze),

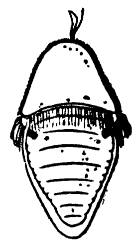
[1] Fig. 133, *d*, foot; *s*, nautilus-like deciduous shell; *v*, velum.

represents the young Tergipes, a naked sea-slug allied to Doris, with its large ciliated velum and foot, the animal being partly surrounded by a large shell (*s*). This shell is finally dropped with the other deciduous larval organs, the gills grow out from the back and the soft elongated body of the adult nudibranch, as this animal is called, is finally attained. It is a singular fact, discovered by Sars, that in the egg-capsules of Dendronotus, as many as six embryos develop side by side.

We will now more carefully study the course of development of a Bulla (*Acera bullata*) as given by Langerhans.

In this animal the yolk of the egg subdivides into two spheres of segmentation, one being much smaller than the other and differing in color. Each of these two cells subdivides into similar halves. The two larger cells then remain passive, while the smaller form a mass of nucleated cells which in two or three days form a layer surrounding the central, inactive yolk cells. On the fifth day arises the first indication of the shell, and on the same day is developed a furrow, the primitive mouth, which separates the cephalic end from the postoral extremity. On the seventh day appear the rudiments of the organ of hearing, and on the day after, the operculum. On the ninth day the pharynx, stomach and intestine begin to develop. On the fifteenth day the otolites are seen in the ear. The liver is next formed, and a few days after the eyes and nerve ganglia, when the larva hatches.

Fig. 134.



Veliger of Chiton.

With the mode of development of Chiton, a cyclobranchiate Gastropod, Lovén has made us acquainted. The larva leaves the egg oval in form, with a ciliated ring in the middle of the body and a long tuft of large cilia on the head. Afterwards it becomes annulated, as in Fig. 134 (after Lovén) and two eye specks appear. Its resemblance to a worm larva is now remarkable. It soon settles down into a quiet life as a Chiton (Fig. 135, *C. ruber*, represents a species found on our shores, from Verrill's Report, after Morse), and the limestone plates correspond to the primitive larval rings.

Fig. 135.

Chiton.

Of the mode of development of the other marine univalve shells (Prosobranchiate Gastropoda), I cannot do better than avail myself of the recent papers of Dr. Salensky. His studies were made

on shells living in the Black Sea, but we have species of Calyptræa and Trochus on our own coast.

Calyptræa sinensis lays its eggs in pear-shaped capsules attached to the same mussel or stone on which it lives. The young of the same brood develop at the same time. Development begins with the total segmentation of the yolk. After it divides into eight cells the blastoderm forms, which consists of a single layer of cells, the result of the subdivision of the first four spheres of segmentation, which grow over and envelop the yolk spheres, thus forming the two germinal layers (ectoderm and endoderm). The cells of the outer layer multiply and form the blastoderm, from which the skin, mantle and external organs, as well as the walls of the mouth arise, while, as in the articulates, the alimentary canal with its dependencies, the liver, etc., arise from the periphery of the yolk cells, the central mass being absorbed.

As soon as the blastoderm is formed, a heap of cells arise and the ectoderm pushes in at a spot which becomes the ventral side of the body. This is the primitive mouth. The anterior part of this cellular heap is the first indication of the "head-vesicle," which becomes a provisional organ well developed in the larva, and is also seen in the embryo fresh-water snails (Pulmonata). The sides of the primitive mouth form the two "sails" of the velum or swimming organ, so characteristic of the larval mollusks, and which was first noticed by Forskal, who wrote on animals just a century ago. Finally, the posterior edge of the infolding, which is also at first a little mass of cells, is the first indication of the foot. The whole surface of the embryo is now covered with cilia, and by their movement the embryo with its fellows, rotates in its capsule.

Fig. 136.

Veliger of Calyptræa.

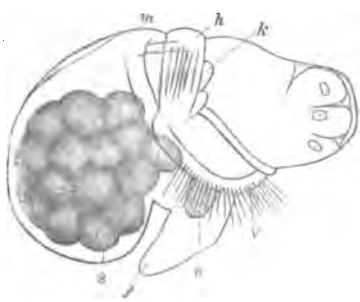
The next change consists in the growth and differentiation of the parts already sketched out. The germ of the foot extends backwards, the mouth-opening deepens and becomes tube-like, the first indication of the pharynx (Vorderdarm). The next most important change is the presence of a layer of cells between the outer and inner germinal layers, which is called the middle germ layer, with cells very unlike the outer layer, from which are developed the muscles of the foot and head as well as the heart

itself. Salensky thinks that this middle layer arises from the outer. It appears first on the ventral side of the embryo. The germ is now of the form indicated by Fig. 136 (*ce*, ectoderm; *'ce*, middle layer, the yolk spheres representing the inner layer, endoderm; *m*, mouth; *v*, velum; *f*, foot. After Salensky).

The next important chapter in the life history of the Calyptræa, is the appearance of the mantle, which arises as a disk-like thickening of the outer germ layer on the back of the embryo. In the middle of the disk the shell grows out as a cup-like cavity which is connected only around the edge with the mantle, but is free in the centre. The ears or auditory vesicles next appear, which, like the eyes, begin as an infolding of the outer germ-layer.

Up to this time the entire body has been symmetrical. Along the longitudinal axis of the body are the foot, the head-vesicle, the germ of the alimentary canal, and on each side a lobe of the velum. The alimentary canal, now further developed, begins to curve to the left, and as the shell grows, the visceral sack, or post-oral portion of the body, hangs over on one side. Not until the organs of sense appeared, the ears with their otolites, and the eyes with their pigment cells, did Salensky discover any trace of a nervous system, and then it was not the cephalic, but the ganglion of the foot which first arises as a mass of nerve cells from the ectoderm.

Fig. 137.

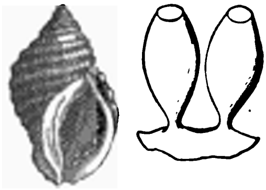


Veliger of Calyptræa farther advanced.

Fig. 137 (after Salensky) represents the asymmetrical larva with the shell enveloping a large part of the body, and the velum (*v*) and foot (*f*) well developed. The larval head forms a third of the whole body and is still finely ciliated. The temporary larval heart (*h*), a large oval vesicle, is situated on the right side of the back of the embryo, between the head and anterior edge of the mantle, in quite a different position from that of the adult heart, which afterwards arises as a new organ. The larval heart contracts rhythmically sixty times a minute. This is an entirely different organ, says Salensky, from the pulsating vesicle or "heart" seen by Duben and Koren in Purpura (Fig. 138, *P. lapillus* and egg capsules, from Verrill's

Report) and Buccinum, or the contractile vesicle found by Semper in Ampullaria, Cypræa, Murex and Ovulum, or the dorsal vesicle of the Pulmonates (snails). There is, however, a similar larval heart in Nassa.

Fig. 138.



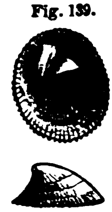
Purpura and Egg Capsules.

At this stage also appears the primitive kidney (Fig. 137, *k*), also a deciduous organ, the permanent, adult kidney arising in another part of the body far behind the larval heart. It resembles the primitive kidneys of the snails (Pulmonates), and appears first as a sort of necklace consisting of four yellowish cells, situated next to the larval heart.

Meanwhile the more the posterior part of the body grows, the larger and more spiral becomes the shell, until the helmet shape of the adult is approached. At this stage also the gill-cavity appears, but there is as yet no trace of the gill itself.

In a succeeding stage the foot has increased in length, the spire of the shell has begun to topple over as it were and fall on one side like a skull cap, and now the adult heart (the pericardium being formed first), and permanent kidney and gills grow out. The gills originate from the ectoderm. It is not until this period that the end of the intestine and anal outlet is formed. The provisional larval organs now begin to disappear, the cephalic-vesicle (larval head) grows smaller, the primitive kidneys disappear. Of the larval visceral organs only the heart remains which, though smaller, still pulsates. It now rests under the mantle in the branchial cavity. There are now two gill-leaves, and finally the permanent heart is formed. The further changes consist in the perfection of all these organs and the development of the shell into the helmet shape of the adult. Fig. 139 (after Morse) represents the common *Calyptræa striata* of our own coast. We have seen that the usual five stages have been undergone, *i.e.* the egg, morula, gastrula (not so well marked as in the pond snail, Fig. 141), veliger and adult.

Fig. 139.



Calyptræa striata.

The metamorphoses of Trochus represent another type of development in the Gastropods, which illustrate points less clearly wrought out in the Calyptræa.

The eggs of *Trochus varius* are very small, spherical, and laid

in masses of jelly on sea weeds. The morula, or mulberry mass, forms as usual. The blastoderm arises from a few small clear spheres of segmentation situated at one pole of four primitive dark morula cells. The four vitelline or primitive cells, instead of remaining passive as in Calyptræa, subdivide, as well as the blastodermic cells. The egg now becomes flattened at one pole and slightly pointed at the other, the latter being the anterior end.

In six hours after development begins, the outer layer begins to form, and the first organ to arise is the velum, which at first consists of a swollen ciliated ring on the anterior end of the embryo. This stage (Fig. 140, A, *v*, velum, after Salensky) is equivalent to the trochosphere (Lankester) of the pond snail. It will thus be seen that the development of Trochus is now very different from that of the Calyptræa, where the velum, head-vesicle and foot arise simultaneously. A little later the mouth and œsophagus arise. Salensky remarks that the Prosobranchiate Gastropods as a rule develop like Trochus. In Vermetus, however, according to the observations of Lacaze-Duthiers, the velum does not arise in the form of a ciliated crown, but as a paired organ. Salensky adds, however, that in other respects there is a strong analogy in Calyptræa to Vermetus and Buccinum and Purpura, which develop like the former mollusk, having a similar larval heart and primitive kidneys, though the mode of development of the external organs is almost wholly unknown. There are thus five genera of Prosobranchiate Gastropods which develop as in Calyptræa, all belonging to the suborder Ctenobranchiata.

On the other hand, *Paludina vivipara*, *Neritina fluviatilis*, and certain Pteropods (*Tiedemannia neapolitana*, *Cavolinia gibbosa*) and a Heteropod (Pterotrachea) are provided, as in Trochus, with a ciliated crown, the first organ lying behind the primitive mouth.

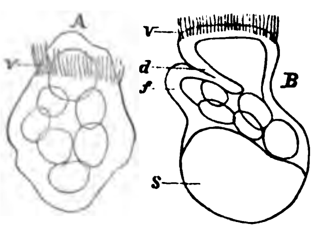
"A good starting point," adds Salensky, whom we have in reality been quoting all along, "for the comparison of the development of Trochus and allied forms, with that of other animals, consists in this stage (Fig. 140, A). A cursory glance at the illustration, will convince one that this condition of the Trochus embryo is similar to the larva of some annelides. Examples of such Annelid larvæ may be seen in some Sabellidæ (*e. g.*, *Dasychone lucullana*) or Spio (*S. fuliginosus*). The latter in escaping from the egg have a more or less oval body consisting of two layers, its only organ

a ciliated crown on the anterior part of the body. The idea of an analogy between the Mollusca and Annelid larva has already been suggested by Gegenbaur. Still more strongly does it follow from these facts, that in the Annelides, as surely as in the Mollusks, the mouth-opening, with the pharynx, arises immediately after the formation of the ciliated crown and somewhat behind the same. Immediately after the formation of the rudimentary pharynx arise the characteristic organs of the two types: in the Annelides the body segments with their appendages; in the Mollusks the foot, shell and two velar lobes."

Salensky then compares the development of Trochus with the Rotifer, Brachionus, and finds some striking analogies. His facts we shall present hereafter in describing from his memoir the life-history of a rotifer.

In the second period of development of Trochus, the true Veliger state is entered upon. The mantle and shell are formed much as in Calyptræa. The body is now flattened, and the ciliated crown projects very slightly. The shell (*s*) has grown considerably.

Fig. 140.



Larval Trochus.

Fig. 140, B, after Salensky, represents this stage. The pharynx (*d*) arises through a tube-like invagination of the outer germ-layer, behind the ciliated crown (*v*). At the same time behind the mouth arises a projection, which indicates the beginning of a foot (*f*). Within the foot, as well as in the anterior part of the body, may be noticed the middle germ-layer, which arises as a layer of cells between the outer and inner germ-layer.

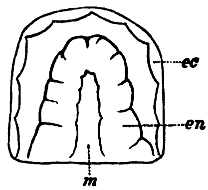
In the following stage the form of the larva is somewhat changed. The shell begins to unroll spirally on the under side of the body. The velum grows more than the middle portion of the head, and the lateral lobes become larger. The operculum also arises on the posterior portion of the foot.

Coming now to the mode of development of the Pulmonate mollusks (fresh-water and land-snails), we find that the aquatic forms undergo a complete metamorphosis, while in the land-snails there is no metamorphosis, and they are hatched in nearly the same form as the adult.

The life history, particularly the earlier stages, of the common pond snail (*Limnæus stagnalis*) of Europe has been worked out with much care by Prof. Ray Lankester, his observations confirming those of Lereboullet, Pouchet and others so far as they extended.

The eggs of Limnæus are deposited in June on the under side of water-plants, in capsules enclosing one, rarely two eggs, and surrounded by a mass of jelly. After segmentation the Gastrula (Fig. 141, *m*, mouth; *ec*, ectoderm; *en*, endoderm) is formed, the primitive digestive cavity or mouth resulting probably from an infolding of the ectoderm. Lankester believes that this orifice or mouth is temporary, the mouth of the adult being a later production. The primitive mouth closes as the embryo enters on the Veliger state, in the earliest stages of which the embryo is oval and surrounded by a ciliated ring, much as in the larval Trochus (Fig. 140, A). This state is called by Lankester the "Trochosphere." A definite Veliger stage is finally attained; the foot is large and bilobed, the mantle and shell then arise and the larva soon passes into the definite molluscan condition, with a shell, creeping foot, mantle-flap and eye-tentacles. The young snail hatches in about twenty days after life begins.

Fig. 141.



Gastrula of the Pond Snail.

Professor Lankester confirms the suggestions already made by Gegenbaur, Morse and Salensky regarding the resemblance of the larval mollusks to young worms. He remarks also that both the Trochosphere and Veliger forms are "well known and characteristic of various groups of Worms and Echinoderms, and the latter is seen in its full development in the adult Rotifera, and in the larval Gasteropoda and Pteropoda. The identity of the velum of larval Gasteropods, with the ciliated disks of Rotifera, seems to admit of little doubt, and it would be well to have one term, *e. g.*, velum, by which to describe both. The Trochosphere is the earlier, more or less spherical form in which the velum is represented by an annular ciliated ridge, and which is sometimes (*e. g.*, *Chiton*) provided with a polar tuft of long cilia.

"The cell, polyblast (morula), gastrula, trochosphere, and veliger phases of molluscan development are not distinctive of the molluscan pedigree; they belong to its præ-molluscan history. The foot, shell-gland, and the odontophore are organs which are

distinctively molluscan—the last characteristic of the higher Mollusca only—the other two of the whole group, and their appearance must be traced to ancestors within the proper stem of the molluscan family tree. The foot is essentially a greatly developed lower lip."

We would add that the Molluscan as well as Annelid Trochosphere may be directly compared (morphologically, not histologically) with the embryo Infusoria (see Fig. 33, E, p. 91) and the ancestry of the Mollusca as well as the Vermes should, as Haeckel declares, be traced back to the Infusoria, perhaps the parent-forms of the entire animal world above the Protozoa.

The usually hermaphrodite Cephalophora, as a rule, to sum up the different phases of their metamorphosis, pass through the following stages:

1. Egg.
2. Morula.
3. Gastrula. (sometimes suppressed?).
4. Veliger (the earliest substage being the Trochosphere, which passes into the generalized Cephalula form; or, restricted to the mollusks, the Veliger stage).
5. Adult mollusk, with foot, shell and often lingual ribbon (odontophore).

LITERATURE.

Sars. Development of Nudibranchs. (Wiegmann's Archiv, 1837, 1840, 1845).

Pouchet. Théorie positive de l'Ovulation spontanée, etc. Paris, 1847.

Leydig. Ueber Paludina vivipara (Siebold and Kölliker's Zeitschrift, 1850).

Koren and *Danielssen.* Bidrag til Pectinibranchiernes Udviklingshistorie. Bergen. 1851, 1856. (Wiegmann's Archiv, 1853).

Kölliker and *Gegenbaur.* Entwickelung von Pneumodermon. (Siebold and Kölliker's Zeitschrift, 1853).

Gegenbaur. Untersuchungen ueber Pteropoden und Heteropoden. Leipzig, 1855.

Claparède. Anatomie und Entwickelungsgeschichte der Neritina fluviatilis. (Müller's Archiv, 1857).

Lacaze-Duthiers. Histoire de l'Organization, du Dévelopment, etc., du Dentales. (Annales des Sciences Nat. 1858).

Lereboullet. Recherches d'Embryologie comparée sur le Dévelopment de la Truite, du Lézard et du Limnée. (Annales des Sciences Nat., 1862).

Salensky. Beitrage zur Entwicklungsgeschichte der Prosobranchien. (Siebold and Kölliker's Zeitschrift, 1872.)

Langerhans. Zur Entwickelung der Gastropoda Opisthobranchiata. (Siebold and Kölliker's Zeitschrift, 1873).

Lankester. Observations on the Development of the Pond Snail. (Quart. Journ. Microscopical Science, 1874.)

Consult also Keferstein, the author of vol. 3 of Bronn's Classen und Ordnungen der Thierreichs; 1862–66; and papers in different journals and transactions of Alder and Hancock, Carus, Krohn, Lacaze-Duthiers, Lovén, Müller, Reid, Schmarda, and Semper.

Development of the Cephalopods. Though the homologies of the Cephalopods with the Cephalophora, particularly the Pteropods, are quite direct, yet the cuttlefishes differ greatly in their mode of growth, particularly in the embryological stages. While the work of Kölliker on the development of the Cephalopods is a classic, yet I shall here avail myself in part of Ussow's more recent work. His observations, made at Naples, are based on two species of Sepia, Sepiola, Loligo and *Argonauta argo*, and they agree so well in their embryology, that the following description answers for all. In the partial segmentation of the yolk, Ussow, as Kölliker before him, was reminded of the same process in the eggs of birds and the turtle. It begins on one side of the yolk; a primitive furrow arising, which is intersected at right angles by a second furrow forming four divisions, afterwards eight, until finally a one-layered germinative disk (blastoderm) is formed on a portion of the surface of the egg, on the second day after development begins. The inner germ-layer then arises, which farther splits into two sub-layers (the outer of which is the dermo-muscular, and the inner the intestino-fibrous).

In Loligo and Sepiola by the 7th or 8th day the germ becomes perfectly spherical and ciliated in portions, so that it rotates in its sac.

In the second period of development, that of the production of organs, the blastoderm covers the entire yolk. The mantle begins to form, next the rudiments of the eyes arise from the ectoderm, and the mouth appears. The embryo is now like a convex disk, or rather a hollow hemisphere.

On the 10th day the gills, funnel, arms and anal tubercle make their appearance, the germ of the gills arising from the dermo-muscular sub-layer of the middle germ-lamella.

On the 11th day the rudiments of the auditory organs, the pharynx and salivary glands arise, as well as the anal orifice, and on the succeeding day the auricles of the heart, the pericardium arising afterwards. The walls of the aorta and of the larger arteries and veins, with the offshoots of the latter (the so-called kidneys), are developed from the cells of the middle lamella, which become elongated and arrange themselves in rows. On the 13th day the ink-sac develops, and the liver. The intestinal tract originates from the primitive invagination of the outer germ-layer (ectoderm) as in Amphioxus, Ascidia, some Cœlen-

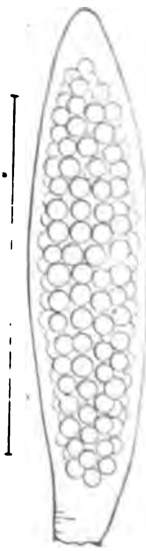
terates, the Brachiopoda, Vermes, etc. As to the mode of origin of the nervous system, Ussow says "I have been compelled to

Fig. 142.

Development of the Cuttle Fish.

give up forever the hope of finding any resemblance to its development in the Vertebrata, Tunicata, Annulosa and Mollusca." All the ganglia of the Cephalopoda originate from more or less compact thickenings of the middle germ-lamella (dermo-muscular sub-layer), as in the peripheral ganglia of the vertebrates.

Fig. 143.



Egg Capsule of Loligo Pealii.

Ussow was unable to trace the origin of the genital glands, as they do not arise until after the animal is three days old, and he could not keep his specimens alive beyond this period.

Now returning to Kölliker's memoir for our information regarding the later stages, Fig. 142, A (*m*, mantle; *b*, branchial processes; *s*, siphonal processes; *a*, mouth; *e*, eyes; 1–5 rudimentary arms, after Kölliker) represents the disk-like embryo resting on the surface of the yolk; B, a side view of the embryo when farther advanced (*y*, yolk sack; *h*, head), and C the same still older, the yolk sac still smaller, the contents having been partially absorbed. Soon after this the body and arms grow longer, and the animal moves about in its shell.

For our information regarding the still later history of our native cuttle fishes we are indebted to the observations of Prof. Verrill, from whose report on the Invertebrates of

Fig. 145.

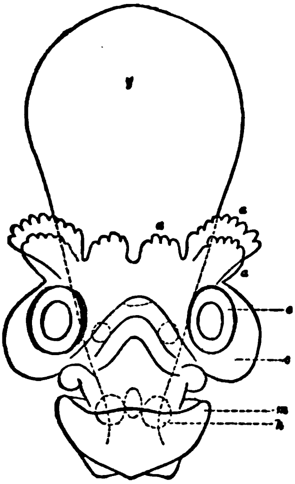


Fig. 144.

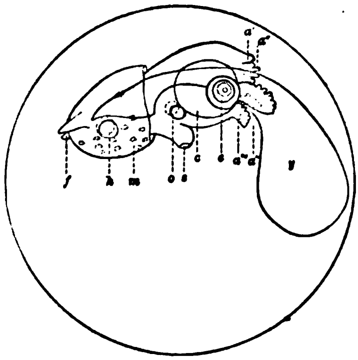


Fig. 147.

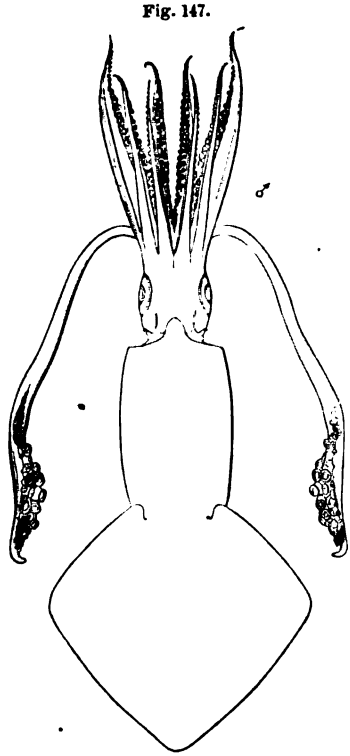
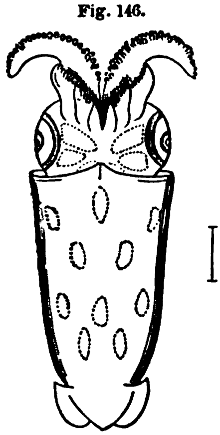


Fig. 146.



Development of a Cuttlefish. After Verrill.

Vineyard Sound in Prof. Baird's U. S. Fish Commission report these cuts are taken. Fig. 143 represents the egg-capsule of *Loligo Pealii.* Fig. 144[1] represents the young of the same cuttle fish, with the yolk sac (*y*). Fig. 145 represents the same farther advanced, while Fig. 146 gives an idea of the same after hatching, the yolk having been completely absorbed. Another species of cuttle fish (*Loligo pallida*) is represented by Fig. 147.

Such is the usual mode of development of the cuttle fishes. But in an unknown form probably over three feet in length, as its mass of eggs was thirty inches long, the mode of development is entirely different. The growth of the embryo is greatly accelerated, and immediately after segmentation it assumes a state analogous to the Trochosphere of other mollusca. To Grenacher's beautiful

Fig. 148.

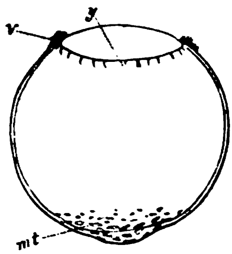
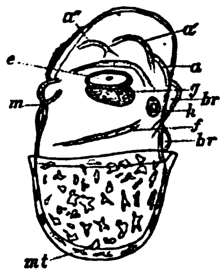


Fig. 149.



Development of an unknown Cuttlefish.

memoir we are indebted for the following facts regarding the life-history of this cuttle fish, whose adult form is unknown. He studied the eggs found floating in the Atlantic ocean, and was unable to raise it to maturity. After partial segmentation, the process being indicated by from five to eight radiating streaks, on the surface of the yolk, the embryo assumed the form indicated by Fig. 148, which represents the blastoderm growing around the under pole of the yolk mass and approaching the anterior end, where there is a swollen, ciliated band (*v*) apparently identical with the velum of the Trochosphere of the lower mollusca. This is an interesting point as Grenacher adopts Lovén's opinion that the arms of the Cephalopods represent and

[1] Fig. 144 *a*, *a''*, *a'''*, *a''''*, the right arms belonging to four pair ; *c*, the side of the head; *e*, the e e; *f*, the caudal fins; *h*, the heart; *m*, the mant in which the color-vesicles are already developed and capable of changing their colors; *o*, th internal cavity of the same; *s*, siphon. The letters in Fig. 145 are the same (after Verrill).

are homologous with the velum of the lower mollusks, particularly the Pteropods, and not with the foot as commonly urged.

This spherical stage is also remarkable for the early appearance of the mantle, with the contractile pigment cells (chromatophores). It will be seen that the entire egg is, as in the lower mollusks, converted directly into the embryo. The embryo soon elongates, the mantle grows, the eyes and arms bud out, and the form of the adult is rapidly sketched out as in Fig. 149 (*m*, mouth; *a*, *a'*, *a''*, arms; *f*, inner and outer funnel-layer; *mt*, mantle, the dotted line ending in a chromatophore; *h*, ear; *g*, optic ganglion; *e*, eye.

We thus have in the embryology of this form, which seems not very different from Loligo (as may be seen in a more advanced stage figured by Grenacher not reproduced here), a mode of development much more like the lower mollusks than was before suspected.

Of the embryology of the fossil Tetrabranchiate Cephalopods (the Ammonites, etc.) we know from the beautiful researches of Professor Hyatt that the shell in Ammonites as well as Goniatites begins as a minute globular sac; in Nautilus this sac "is not retained, but traces of its former existence are apparent on the apex of the first whorl, in the form of a scar or cicatrix."

Summarizing the known facts regarding the living, dibranchiate Cephalopods, we have eggs and spermatic particles developed in separate sexes, the egg passing through the following phases.

1. Partial segmentation, analogous to that of Vertebrates.

2, *a*. Trochosphere (?) or germ developing on the surface of the yolk and gradually absorbing it; the Gastrula state suppressed; or, as is more usually the case (*b*), the adult form is directly attained.

LITERATURE.

Kölliker. Entwickelungsgeschichte der Cephalopoden. Zürich. 1844.

Hyatt. Embryology of the Tetrabranchiates. (Bulletin. Mus. Comp. Zool. 1872).

Lankester. Development of the Cephalopoda. (Annals and Mag. Nat. Hist. 1873, and Quart. Journ. Micr. Sc. 1875).

Grenacher. Zur Entwickelungsgeschichte der Cephalopoden. (Siebold and Kölliker's Zeitschrift. 1874).

Ussow. Zoologico-Embryological Investigations. (Annals and Mag. Nat. Hist. 1875).

Consult also the writings of Van Beneden, Metschnikoff, D'Orbigny, G. & F. Sanberger, Barrande and Verrill.

REVIEWS AND BOOK NOTICES.

THE HERPETOLOGY OF EUROPE.[1]—In this work we find the fullest list of European Batrachia and Reptilia which has ever been brought together. They are characterized by full descriptions, each of which is accompanied by an outline figure of the more essentially distinctive parts of the animal. As a manual for the determination of the species of European Reptilia, this work appears to be the most convenient in existence, providing the classification be not taken into account. It is also full in the matter of geographical distribution, supplying a want which has long been felt especially by extra European students.

Since the work is stated on the title page to be "Systematische Bearbeitung," it may be well to take a glance at the system adopted. We find that the Batrachia are arranged in accordance with the system, or rather want of system, of fifty years ago. The important structural features which distinguish the crania of the salamanders, pointed out by Gervais, Gray and others, are not regarded as of sufficient weight to affect the classification. In consequence the genus Euproctus is united with Triton, and Geotriton with Spelerpes. The arrangement of the frogs and toads is still more remarkable. But one of the four genera embraced in the Pelobatidæ belongs to it, and this genus Pelobates embraces two well defined genera of authors. The typical species of one of these *Didocus calcaratus* is regarded as a synonyme of the very distinct *Cultripes provincialis*. Of the three remaining genera, two belong to the *Discoglossidæ*, the type genus of which, *Discoglossus*, is placed in the Ranidæ, a group which stands in the remotest relation to it consistently with reference to the same order. In the Anura as in the Urodela, osteological characters, the only reliable ones, are quite neglected.

Among the serpents we notice with regret the substitution of the time-honored Coluber by Callopeltis of later nativity, and Periops is scarcely different from Lamenis. The family characters are derived from the dermal scuta, which are quite inadequate for such service. Characters of like inefficiency figure in the di-

[1] Herpetologia Europaea: Systematische Bearbeitung der amphibieon und reptilien w. in Europa aufgefundsind von Dr. Egir Schreiber, Brunswick, 1875.

agnoses of the families of Lacertilia, hence we find the Agamid genera referred to the Iguanidæ, and Opheomorus and Anguis to the Scincidæ!

The review of geographical distribution at the close of the volume is valuable in proportion to its completeness, which the date of the work in a measure guarantees. But with every appreciation of the value of the author's species work, the absence of systematic analysis deprives his book of the scientific merit which would otherwise belong to it.—E. D. C.

THE DISTRIBUTION OF INSECTS IN NEW HAMPSHIRE.[1]—The author, in this interesting essay, discusses with his characteristic thoroughness the relations of the faunæ (Alpine, subalpine, Canadian and Alleghanian) which have their representatives in that state. It is illustrated by a map of the state, showing the relations of the Canadian and Alleghanian faunæ, and another of the Alpine and subalpine regions of the White Mountains. The data are drawn from the butterflies and grasshoppers. We were not aware that such excellent material existed for such a full discussion of the subject, which will, we doubt not, greatly stimulate further studies on the geographical distribution of insects in this country.

PRINCIPLES OF METAL MINING.[2] — This is a compact, clearly-written and well illustrated little manual by a practical miner and member of the London Geological Society. The author has adapted it for the instruction of young miners starting in life. We have not met with a better and briefer introduction to the art of mining for the general reader.

BOTANY.

FUCUS SERRATUS AND FUCUS ANCEPS. — I have received from Prof. A. F. Kemp, of Knox College, Galesburg, Ill., specimens of *Fucus anceps* Harvey, and *Fucus serratus* Linn., with the following notes concerning them which will be interesting to marine botanists.

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[1] The Distribution of Insects in New Hampshire. A chapter from the first volume of the Final Report upon the Geology of New Hampshire. By S. H. Scudder. Concord, 1874. Royal 8vo. pp. 331-380. With two maps and a plate.

[2] Principles of Metal Mining. By J. H. Collins. Putnam's Elementary Science Series. With 76 illustrations. New York, G. P. Putnam's Sons. 12mo, pp. 149. Price 75 cents. For sale by A. A. Smith & Co., Salem, Mass.

I very much doubt whether *F. serratus* ever grew on our coast. I am not aware that any botanist has found it *in situ* or in such a condition as to warrant the belief that it was indigenous. In June, 1869, I found it in Pictou Harbor, Nova Scotia, but only in moderate quantity and attached to movable stones. It had all the appearance of being introduced from Europe, the European ships coming for lumber were accustomed, I was told, to discharge their ballast in the deep water of the harbor. This ballast, to my knowledge is often taken from the sea-shore. In this way I think the plant has been brought to this coast. It would be interesting to know whether the plant has been found anywhere else. Dr. Harvey's authority for assigning it to our coast is doubtful. * * *

At Peak's Island I found a form of *Fucus*, very abundant there but not noticed anywhere else. I sent it to Dr. Harvey who acknowledged it to be new to the Atlantic coast, and like a Fucus lately found in Ireland which he said was named "*Fucus anceps*."

It grows very large, has the habit of *F. serratus* but wants the serratures. It grows just at low water mark and is never altogether free from the moisture of the sea. I have observed places north and south of Peak's Island, but have never seen a specimen anywhere else.

It looks so much like the young of *F. vesciculosus* that it is apt to be taken for it, which it certainly is not.

A specimen sent me by Harvey is much less robust than mine, very diminutive indeed but seems to have a like form.—D. S. JORDAN.

GENTIANA ANDREWSII.—In one of the numbers of the NATURALIST for 1874, some remarks were offered by a correspondent, regarding the fertilization of this species by humble bees. It was assumed since the stigma and its style also project some distance beyond the anthers, that this species needs the assistance of insects to become properly fertilized. The stigma is brought in contact with the pollen in the natural development of the flower. In the bud the epipetalous stamens and their cohering anthers are superior to the stigma. The latter is raised by the growth of both style and ovary, but especially the ovary, and pushed up through the ring of the cohreing anthers, but not until they have matured their pollen. This they shed so plentifully as to bury completely the stigma for the time being, and fertilize it even

more effectually than could possibly be done by humble bees in the manner suggested by your correspondent. Observation will fully establish the main fact of this statement.—M. W. VAUSENBURG, *Ft. Edward, N. Y., Apr.* 10, 1875.

STENOGRAMMA INTERRUPTA.—In Grevillea for December, 1874, is an article by Mr. E. M. Holmes, "On *Stenogramma interrupta* Harv.," in which the writer states that Harvey had never published an account of the tetraspores of that plant, of which material had been sent him by Miss Gifford. In the "Nereis Amer. Bar.," Part II, p. 162, Harvey acknowledged the receipt of Miss Gifford's specimens, and gives a full account of the literature of this species, which is *Stenogramma interrupta* of Montague, not of Harvey as Mr. Holmes has it.—W. G. FARLOW.

A DIRECTORY OF AMERICAN BOTANISTS has appeared in the "Bulletin of the Torrey Botanical Club," New York. Also description of new fungi from New Jersey, with other notes of value to working botanists.

PRESERVING FUNGI.—A good method for the preservation of Fungi is to place them in a solution of 1 part calcic chloride, 10 parts hydric oxide. This will change the phosphates in the fungus into phosphate of lime (calcic phosphate), after which they will be found to keep well.—J. H. MARTIN.

VOLVOX.—A work by Dr. F. Cohn on the developmental history of the genus Volvox has lately appeared.

NORTH AMERICAN FUNGI.—The Rev. J. M. Berkeley continues his notices of our Fungi in "Grevillea."

ZOOLOGY.

NEW PHYLLOPOD CRUSTACEANS.—I have received from Dr. E. Coues, naturalist of the United States Northern Boundary Commission, a collection of these animals which he writes "occurred in myriads in several small prairie pools from a hundred yards to a half mile or so wide, exactly on the Boundary line, 49° N., just on the west bank of Frenchman River, Montana. You will not find this stream on the map, perhaps, by this name; it is one of the first of the whole series of similar streams flowing south into Milk River. The species was not observed elsewhere. The ponds were extensive shallow sheets of sweet water, of a comfortable

wading depth, generally with a little open space in the deepest part, but mostly choked with luxuriant vegetation (Gramineæ, Utricularia, etc.). Date of collection first week in July."

The occurrence of the Apus-like form, which may be called *Lepidurus Couesii*, is of much interest, as the genus has not before occurred on this continent south of the Arctic regions and Greenland, where *L. glacialis* occurs. Our western species, however, more closely resembles *L. productus* from Europe, but differs in the much longer telson, which is long, slender and spatulate. In this character, and its much longer carapace it differs from *L. glacialis* from Greenland. It also differs from *L. productus* in the eyes being closer together and more prominent.

In the males the carapace is a little shorter, and the telson twice as large as in the other sex, being three or four times as long as that of *L. productus*. Thirty-two males and thirty-one females occurred. This equality in the number of the sexes is noteworthy.

With these occurred a new Lymnetis with eggs. It is intermediate in size between *L. Gouldii* and *L. gracilicornis*, but more spherical than either. It may be recognized at once by the much produced, mucronate front, which in the two other species is broad and spatulate and square at the end. From this character it may be called *Lymnetis mucronatus*. Length .10–.13 inch.—A. S. Packard, Jr.

Artificial Hatching of Grasshoppers.—I recently noticed the hatching of grasshoppers under such peculiar circumstances that I thought them worthy of public mention. I was travelling with U. S. Troops in the southwestern part of Dacota Territory, through a region which had been visited by the flight of grasshoppers of 1874. It was January and the weather intensely cold. We generally came into camp each day at 4 P. M., when the snow was cleared off, tents pitched and fires lighted in them, which soon thawed out the ground and heated it for some distance around. The fire was not kept burning more than five hours at any camp, yet often the next morning young grasshoppers were seen skipping about as full of life as though they had not been subjected to such an unusual forcing process.—W. L. Carpenter, *U. S. Army, Camp Robinson, Neb., Jan.* 17, 1875.

[It seems probable to us that the larvæ of the Caloptenus hatched in the autumn before the snow fell, as those of other and allied grasshoppers do in New England.—Eds.]

Dendroica dominica in Indiana.—Dr. Coues notices in the Naturalist for July, 1873, the occurrence of *Dendroica Dominica* Baird, "so far north" as Kanawha Co., West Va., as stated by Mr. W. D. Scott.

I shot in Indianapolis, Sept. 25, 1874, an individual of that species, apparently intermediate between the varieties *Dominica* and *albilora* as given by Baird, having the part of the superciliary stripe before the eye strongly tinged with yellow, and the yellow of the chin and maxillæ narrowly bordered next the bill with white.

Seiurus Ludovicianus Bp. I found last year about Green Bay, Wisconsin, in some abundance in the latter part of April.—D. S. Jordan.

The Whistling Swan.—A fine adult specimen of the whistling swan (*Cygnus Americanus*) was obtained on the 20th inst., by James Logan, near Shelbyville, in this state. It measured eighty-four inches from tip to tip of the wings. It was shot while feeding along a small stream of water in company with two others, one of which, from its brown color, was evidently young. The swan is exceedingly rare in this state, only stopping occasionally on its way to the North.—E. S. Crosier, *Louisville, Ky., March* 27, 1875.

Habits of Snails.—A specimen of *Helix pomatia* lived for eleven months without feeding, and slept for seventeen weeks. Its weight was diminished by 0·13 gr., or 0·6 per cent. daily.—J. V. Sivers, C. B. Ver. Riga. (xix, p. 112), *Zoological Record for* 1872.

GEOLOGY AND PALEONTOLOGY.

Fossil Batrachia in Ohio.—Prof. J. S. Newberry, director of the geological survey of Ohio has made additional collections in the fossil-bearing coal-measures. Land vertebrate remains of that age have as yet been only found in Ohio within the limits of the United States, and the specimens are noted for their singularity and beauty. Thirty-three species of Batrachia have been found; but no reptiles nor higher vertebrata. One of the novelties is a species of the genus Ceraterpeton, the first time a European genus has been detected in this country. This form is as large as a rat, and has a pair of stout horns on the back of its head, in the posi-

tion and having much the form of those of the ox. The skull is sculptured by rows of small pits, separated by fine radiating ridges.—*Independent.*

THE PROSPECT OF VOLCANIC ERUPTIONS IN THE WEST seems to be good if the opinions of the geologists of Wheeler's Expedition are correct. "In the past they have occurred so recently that it is, indeed, surprising that there is no human record of them," and eruptions may take place at any time in the future. In Southern Utah they ascertained that there are connected floods of lava covering an area of 5,000 square miles, while in Arizona and New Mexico there is an area not less than 20,000 square miles in extent, and never before recognized as a connected belt.

GLACIAL PHENOMENA IN UTAH.—The southern limits of the ancient system of glaciers has been ascertained by the geologists of Wheeler's Survey, through the entire extent in longitude of the Survey, and an attentive examination has been made of the record of an expansion of Great Salt Lake, which occupied the valleys of Utah, while the highest mountain gorges were choked with ice.

ANTHROPOLOGY.

CLAY "HUNTING-WHISTLES."—There occasionally occurs among the relics of central New Jersey, found upon the surface, short, cylindrical tubes of fire-baked clay, measuring from one and one-half to two inches in length, slightly tapering, being half an inch or slightly larger at one end, and about three-eighths of an inch at the smaller end. These tubes I have always considered as

Fig. 150.

simply pipe-stems, and such, in fact, they may be; but two facts connected with them, now suggest the possibility of their having been utilized as whistles (?). Every specimen met with has been very carefully squared at the end which joined the bowl of the pipe, if the specimens are pipe-stems, showing that they were utilized after the fracture occurred. Considering, however, the great abundance of fragments of clay pipes, it seems strange that

no broken stems, *not smoothed* at the broken end should be found. Split stems, and fragments of bowls are met with, and occasionally an entire pipe. The specimen figured (150) giving a good idea of the whole series as found by me, was taken from an "Indian" grave, associated with the usual "find" of relics so occurring. This fact seems to indicate that whether utilized pipe-stems or implements *de novo*, they had some special use; and I suggest that such use was as whistles. By placing the thumb over the basal or larger opening, and holding the specimen at right angles to the lips, it requires but a slight blowing effort to make a remarkably shrill clear whistling, which can easily be heard a quarter of a mile. In the hands of the aborigines, accustomed to their use, no doubt a much shriller "call" could be made with them. Of course the whole matter is an undeterminable one, but I suggest this as a plausible explanation of the presence of considerable numbers of this peculiar relic.—CHARLES C. ABBOTT, M. D., *October*, 1874.

THE BRONZE AGE IN SWITZERLAND.—The Memoirs of the Society of Natural Sciences of Neuchâtel (Tome. iv, part 2), contains a beautifully illustrated memoir on the bronze age in Switzerland, especially of the Lacustrian inhabitants.

MICROSCOPY.

A SECTION CUTTER FOR HARD OBJECTS.—Dr. George Hoggan's section machine, as described at the Queckett Club, differs radically from the tubular style of section cutters in common use. According to the inventor's assurance, which is fully justified by the appearance of his contrivance, he had at the time of its construction never seen a section cutter of any kind, and to this fact he attributes the originality of his conception. The object to be cut, instead of being packed in a tube, is (protected by slices of carrot or pieces of paper) fastened by means of a clamp and binding screw upon a sliding support or "table" which is moved in a grooved track at right angles to the course of the saw or knife by a screw capable of giving a graduated motion of $\frac{1}{500}$ inch. On each side of this sliding table, and attached to the bed-plate on which it slides, is an upright guide-bar to serve as a lateral support for the instrument making the sections. Hard sections, as of bone, are cut with a fine saw, what is called the "Pearl saw" being the best, which, like all other saws, should in Dr. Hoggan's

opinion, be mounted so as to cut during the pulling and not during the pushing stroke. The saw cuts sections of bone at the rate of one in two to three minutes, which are sufficiently thin and smooth, and only require to be washed free from sawdust to be ready for mounting. The saw frame being thicker than the blade, the upper part of each of the guides is set back so that the blade and frame of the saw will both move in the same perpendicular plane. Both blade and frame are held against the guides by steel springs, the face of the guides being also protected by hardened steel, securing a correct path for the saw independently of the skill of the operator. For cutting soft tissues, with a razor, the instrument is turned so that the cutting is done in a horizontal instead of a vertical plane, the object being arranged on the sliding table by means of a tray. The cavity most convenient for ordinary work will contain a $1\frac{1}{2}$ inch cube of the material to be cut, though it may be so enlarged as to permit the cutting of a section of 4×6 inches.

RECENT OBJECTIVES.—Mr. Charles Brooke in his President's Annual Address before the Royal Microscopical Society, makes some interesting suggestions in regard to last year's improvements in object glasses. A "remarkably fine $\frac{1}{8}$th" by Powell & Lealand, with an avowed single-front lens is mentioned, but its principle of construction is not discussed, as it has not been made known by its makers.

Increased flatness of field has been obtained in objectives constructed on Mr. Wenham's formula, by replacing the original single plano-convex posterior lens by two plano-convex lenses of proportionally less curvature. Mr. Brooke possesses a $\frac{1}{7}$th thus improved, which excels in definition any other objective in his possession. It defines well with the sixth eye-piece of Ross, which however, he would never think of using except as a test of definition.

The fog which is so conspicuous a defect in some otherwise excellent glasses, he suggests may be partly due to the multiplication of cemented contact-surfaces, and that it may be so excessive in certain cases because of increasing not in the simple ratio of such surfaces, but in proportion to the square of that number, as if an objective with four cemented surfaces should have four times as much fog as one with two such surfaces.

Personal Equation in Microscopy.—The "Monthly Microscopical Journal" gives the following excellent summary of Mr. Ingpen's interesting communication on the above subject to the Queckett club:—

"Mr. Ingpen communicated some notes on 'Personal Equation,' with reference to microscopy. He first explained the use of the term in astronomy, as exemplified in transit observations, and in its more extended differences by a constant quantity between observers, short of actual defects of vision. The same causes affected microscopical observation, though they were not so well recognized as in astronomy. The principle points referred to were the following: I. *Mental* equation, as causing differences in interpretation, particularly with regard to test-objects. II. *Nervous* equation, as shown by varied sensibility to tremors, etc. III. *Color*. Difficulty in estimating color, as noted in Admiral Smyth's 'Sidereal Chromatics.'—Right and left eye often differ in this respect.—Effect of yellow crystalline, referred to by Professor Liebreich in his lecture on 'Turner and Mulready.'—Difference in visibility in violet end of the spectrum, amounting in some cases to slight fluorescence.—Effect of red and yellow grounds in increasing definition in certain cases.—Effect of bluish mist caused by slight opacity of cornea or crystalline upon estimation of the correction of objectives.—Color blindness often existing in a slight degree unsuspected, and difficult of detection. IV. *Focal equation*. Differences in effect of long and short sight upon cover correction, etc., also upon depth of focus, and power of resolving surface markings.—Differences in size of images formed by right and left eye, and consequent effect upon binocular vision.—Want of accommodation, and pseudoscopic vision, etc. V. *Form*. General tendency of the eye to show ultimate particles circular.—Effect of square and triangular apertures.—Effect of astigmatism upon form, particularly of lines and dots, as seen in different directions.—Reference to Professor Liebreich's lecture.—Effects of diffraction upon points of light, etc.—General considerations of the effects of unnoticed differences of vision producing discrepancies often attributed to other causes."

The microscopists seem no more agreed than other critics, as to the peculiarities of the later Turner pictures, as "Mr. J. G. Waller differed from Mr. Ingpen with reference to the later pictures of Mulready, which Professor Liebreich considered to show the effect of yellow crystalline; and gave reasons for thinking that the blueness of those pictures was due to their unfinished condition. He thought also that Turner's later pictures showed extravagant mannerism which could be thrown aside at will."

Pigment-Particles.—Dr. J. G. Richardson's suggestion that particles of dried blood which washing has failed to remove from

the irregular surface of previously used glass slips or covers have been habitually mistaken for recent objects and have become familiarly recognized as pigment-particles, is discredited by Mr. Brooke, who does not believe such a theory applicable to the work of experienced microscopists.

NOTES.

Mr. R. U. Piper in an article in a daily paper on the use of Paris green in killing potato beetles, warns people against its use as it is a deadly poison. A single grain is sufficient to cause death, and a little of the dust received into the system from time to time is extremely dangerous. M. de Kerchove also deprecates the use of the arsenite of copper (Scheele's or Paris green) as too dangerous a substance to be made common. Its careful use during the coming season should be inculcated.

Sir Charles Lyell has bequeathed $10,000 to the Geological Society of London, "for the encouragement of geology, or of any of the allied sciences by which they shall consider geology to have been most materially advanced, either for travelling expenses, or for a memoir or paper published or in progress, and without reference to the sex or nationality of the author, or the language in which it may be written."

Dr. Hofmann, of Berlin, recently delivered the Faraday Lecture of the Chemical Society at London. At a dinner, when one hundred and eighty scientists were present, "probably," says "Nature," one of the most remarkable scientific dinners that have taken place for some years, he made a noble appeal in behalf of the recognition of the high value of pure scientific research.

Dr. Steindachner recently read a paper before the Imperial Academy of Sciences at Vienna, on the river fishes of the south-eastern coast district of Brazil, from the mouth of the La Plata to that of the San Francisco.

Daniel Hanbury, the joint author (with Dr. Flückiger) of a late work entitled "History of Drugs" died March 24th, aged 49. He was an F. R. S. and treasurer of the London Linnæan Society.

Dr. H. R. Goeppert, the venerable professor of botany at Breslau, celebrated the fiftieth anniversary of his graduation, Jan. 11th.

ACTING-GOVERNOR Van Zandt has appointed George H. Wilson member of the commission to prepare plans for a geological and scientific survey of the State of Rhode Island, in place of Hon. Rowland Hazard, declined.

PROF. M. FOSTER and A. G. DEW-SMITH lately read a paper before the Royal Society "On the behavior of the hearts of mollusks under the influence of electric currents."

PROF. ASA GRAY, at a meeting of the French Academy held on the 16th March, was elected an honorary member in the department of science.

JUST as we are going to press, we learn that the bill for the scientific survey of Massachusetts failed to pass the House, but the vote (nearly a tie vote) in its favor was so large as to indicate that public sentiment strongly demands a resurvey of the state. The movement in Massachusetts has extended to Connecticut and Rhode Island, while the recently published report of Prof. Hitchcock, as state geologist of New Hampshire, is a credit to that state. We look confidently to the institution, within the next year or two, of resurveys of nearly all the New England states.

IT seems that our paragraph taken from a Swiss paper regarding the block of granite designed to cover the grave of Agassiz, contained some errors. The bowlder in reality came from the terminal moraine. Judging from its position when removed, it must have formed part of the median moraine, and have been about 7,000 feet higher up where Agassiz lived on the Aar glacier. It probably came originally from the "Abschwung."

THE University of Wisconsin at Ann Arbor has received an appropriation of $80,000 from the legislature for building a Science Hall.

WE have received from Mr. C. F. Dennet an interesting pamphlet entitled "Vegetable Fishes," with special reference to the textile fibres, etc.

THE fifth volume of the Annals of the "Museo Civico" of Genoa is devoted to an elaborate memoir on the birds of Borneo, by Salvadori, of Turin.

A PROPELLER has been invented to imitate the action of the dorsal undulating fin of the pipe fish and sea-horse.—*Nature.*

The Signal Service office at Washington, is to publish in its weather reports, the more apparent phenological phenomena, *i. e.*, the times of flowering of plants and appearance of animals in the United States.

It seems that a species of Peronospora, the same genus of fungi as that which occasions the potato rot, infests the opium crop of India very seriously, causing the blight.

ANDERSON SCHOOL OF NATURAL HISTORY, SESSION OF 1875.

Owing to the impossibility of carrying on the Anderson School of Natural History at Penikese, on the same terms as formerly, the trustees have decided to charge a fee of fifty dollars for the coming session. The price of board will be fixed at the lowest possible terms. The course of study, for the season of 1875, will be announced at an early date. It is very desirable that application for admission be made at once to the director. Preference will be given to teachers.—Alexander Agassiz, Director. *Cambridge, April* 20, 1875.

BOOKS RECEIVED.

An essay concerning Important Physical Features exhibited in the valley of the Minnesota River, and upon their signification. By G. K. Warren. Washington, 1874. pp. 22. 8vo.

Report of the Commissioner of Education, 1873. Washington, 1875. pp. 1048. 8vo.

Bulletin de la Societe Geologique de France. Paris, IIIe Serie, Tome 1. Nos. 1-5, 1873. Tome II. Nos. 1-6, 1874. Tome III, Nos. 1, 2, 1875. 8vo. *Reunion Extraordinaire a Raonne.* Aug. and Sept. 1873. 8vo.

Geological Survey of Alabama, Report of Progress for 1874. By Eugene A. Smith. Montgomery, 1875. pp. 139. 8vo.

Geological Survey of Canada, Report of Progress for 1873-74. Montreal, 1874. pp. 268. 8vo.

Proceedings of the Academy of Natural Sciences of Philadelphia. 1875, pp. 153-266. 8vo.

Quarterly Journal of Microscopical Science. London, Oct. 1874. pp. 323-430, Jan. 1875. pp. 106. 8vo.

Sitzungsberichte der physikalisch-medicinischen Societat zu Erlangen. Erlangen, 1874. pp. 177. 8vo.

Jenaische Zeitschrift fur Naturwissenschaft. Jena, 1874. VIII Bd. N. F. 1., Bd. 3. pp. 237-480. 8vo.

Vegetable Fibres, with special reference to the Textile Fibres, Rhea or Ranue, Jute, New Zealand Flax. Their uses and abuses. Brighton and Sussex Natural History Society. By Charles F. Dennet. Brighton, 1875. pp. 8. 8vo.

Bullettino della Societa Entomologica Italiana. Firenze, 1874. Anno Sesto, Trimestre, 1, 2, 3, 4. 8vo.

Jardin Imperial de Botanique de St. Petersburg. 1874. Vol. III. No. 1. pp. 168. 8vo.

Annual Report of the State Geologist of New Jersey, for the year 1874. Trenton, 1874. pp. 116. 8vo.

Elementary Collection of Minerals and Rocks, with Brief Descriptions. By Rev. E. Seymour. New York, 1874. pp. 37. 8vo.

The Transactions of the Academy of Science. St. Louis, 1875. Vol. III, No. 2. 8vo.

Tidsskrift for Populære Fremstillinger af Naturvidenskaben. Kjobenhavn, 1875. Andet binds, Forste Hæfte. 8vo.

The Entomologist's Monthly Magazine. London, Apr. 1875. 8vo.

Societe Entomologique de Belgique. Serie II, No. 10. pp. 10. 8vo.

The American Journal of the Medical Sciences. Philadelphia, April, 1875. 8vo.

Jahrbucher des Nassauischen Vereins fur Naturkunde. Wiesbaden, 1873 and 1874. xxvii and xxviii. pp. 258. 8vo.

Verhandlungen des naturhistorischen Vereines der preussischen Rheinlande und Westfalens. Bonn. Dritte Folge, Jahrgang 10. Pt. 2, 1873. Vierte Folge, Jahrgang 1, Pt. 1. 1874. 8vo.

Sitzungsberichte der Gesellschaft Natur-forschender Freunde Zu. Berlin, 1874. 8vo.

Deutsche Entomologische Zeitschrift. Jahrg. xix, Heft 1. 1875. 8vo.

Entomological Society of the Province of Ontario, Report of 1874. Toronto, 1875. pp. 62. 8vo.

THE

AMERICAN NATURALIST.

Vol. IX.—JUNE, 1875.—No. 6.

THE POTTERY OF THE MOUND BUILDERS.

BY F. W. PUTNAM.

By the courtesy of the Trustees of the Peabody Museum of American Archæology and Ethnology, Cambridge, we are able to give the following account of the very interesting collection of articles, principally of pottery, from mounds in Missouri, forming the Swallow Collection which was secured by the Museum last year, and now recorded in the Eighth Annual Report of the Trustees made to the President and Fellows of Harvard College.

On the decease of Professor Wyman, the late Curator of the Museum, in September last, the Museum was then placed in charge of Professor Gray, as temporary Curator, who requested Mr. Putnam to write a report on the acccessions to the Museum during the year, and the following extract is from the report addressed by him to Professor Gray.

To enable a ready comparison to be made with the several vessels referred to in the text as having been described in Col. Foster's "Prehistoric races of the United States," the woodcuts illustrating Col. Foster's article in a former number of the Naturalist are reproduced at the end of this article.

The collection made by Prof. G. C. Swallow, recently secured by the Museum, is an important addition, particularly in articles of pottery and stone of the moundbuilders, and as a number of woodcuts representing many of the most interesting of the articles were received with the collection, they are here inserted

together with the following abstract from the manuscript by Professor Swallow.

"We opened these mounds in December, 1856, and the following month. There were present, assisting with their servants and teams, Messrs. S. R. Phillips, John Martin, M.D., Clayton Lee, John Jackson, M. Jackson, Elijah Horrel, Dr. Case, Daniel Fulton, A. E. Sheelds of New Madrid, Missouri, and Geo. Northcutt of Columbia and some others.

"We cut a passage six feet wide entirely through the "Big Mound" from side to side and from top to bottom, laying open its entire structure.

"This mound is in Lewis' Prairie, west of New Madrid. It is elliptical in form, 900 feet in periphery at the base, 570 feet at the top which is nearly level and about 20 feet above the surrounding country. This is the wide bottom of New Madrid county some 60 miles long and 30 to 40 wide, and is known as the swamp country. This was the country effected by the New Madrid earthquake of 1811.

"A room seems to have been built by putting up poles (like rafters in the roof of a house); on these rafters were placed split cane (*Arundinaria macrosperma*); plaster, made of the marls of the bluff formation, was then applied above and below so as to form a solid mass, inclosing the rafters and lathing of cane, and this held all in place; over this room was built the earth work of the mound, so that when it was completed the room was in its centre. The earth work was then coated with the plaster, and over all nature formed a soil.

"This mud plastering was left rough on the outside of the room, but smooth on the inside which was painted with red ochre. (One of the pots found had been used as a paint pot).

"Some of the plastering was burned hard as brick, but other parts were only sun dried, as shown by the pieces sent.

"Some of the rafters and cane lathes were found decayed, some burned to coal and others all rotted but the bark. Some of the rafters were, probably, of cypress, and others, of elm. This inner plastering was found flat on the floor of the room as it had fallen in, and under it were the bones and pots, the latter including one that contained a human skull, which we found at one side. This vessel was first hit by the point of the plow. It was bottom up, and not broken nor even cracked when I took it out of its

resting place, the skull within was not broken and could not be taken out without breaking it or the pot, a fact which attracted much comment at the time. I remember one remark of Mr. Phillips.—"The pot was made over the person's head as a punishment." The pot[1] and skull were afterwards broken by an accident to the box in which it was packed.

"All the articles in this mound were well preserved as the plastering protected them from the elements."

The character of the articles found in the "Big Mound" mentioned in the foregoing account by Prof. Swallow, will be understood from the following short descriptions and accompanying illustrations. The woodcuts, though rather roughly executed, are generally quite characteristic of the articles represented. The numbers used in the descriptions and to designate the figures are those under which the articles are entered in the Museum Catalogue.

The clay in some of the vessels has been mixed with more or less finely pounded shells, probably of fresh water muscles. In other instances the pounded shell has not been used, but fragments of charcoal are to be traced, indicating that either charcoal itself was used to temper the clay, or else, which is more likely, that some vegetable substance was mixed with the clay, which, in burning the vessels, was reduced to charcoal. In a few of the specimens sand was mixed with the clay, and in several, the clay was apparently without any mixture. These last are generally thick and rude in their finish, while those in which charcoal is now seen are generally the thinnest and among the more finely finished vessels, as in No. 7800.

Many of the vessels from these Missouri mounds show evidence of having been heated both on the inside and outside; but several appear not to have been so heated, and these are not so finely and smoothly finished as those which have been hardened by fire.

The best finished of these vessels have the appearance, noticed by Squier and Davis in other specimens from the mounds, of having been carefully shaved by a sharp knife on the outside. The same appearance is observable in the dark, Peruvian pottery. It is possible that this was produced by making the clay on the outside of

[1]This vessel is represented as Fig. 7761; a small portion of it is missing from near the bottom, and a few fragments of a human cranium and the vertebra of a *deer* are now in it. Prof. Swallow has made mention of this skull in the Proceedings of the Amer. Assoc. Adv. Sci., xxii, B, 401.—F. W. P.

the vessels very wet and then hastily smoothing it just before it was baked. The unburnt specimens do not have this peculiar, smooth surface.

No. 7776. A jar surmounted by the figure of a woman sitting upon her feet, represented by the two lower protuberances, as seen in the figure giving the back view. The upper of the three pro-

No. 7776.

jections shown in the figure represents the curve of the back, and the front view shows the hands resting on the knees. This jar is 7·7 inches high, and 5·8 inches in greatest diameter. The bulging part has a nearly even diameter varying but ·2 of an inch. The jar is slightly flattened at its base so as to stand without tipping. The opening at the back of the head is one inch in transverse diameter by ·8 vertical.

No. 7775. This very odd vase or jar is made in the form of a woman represented in the same squatting position as that surmounting jar No. 7776. The jar is perfect, though, from the clay being less finely tempered than in the preceding, the features are not so strongly defined. Each ear is perforated by a small hole, and the pointed portion on top of the head probably indicates a different style of head dress from that of 7776. The back is represented as very much protruded, the breasts are large and well

formed. The dimensions of the vase are as follows: total height 4·6 inches; from knee to end of foot 2·5; from breasts to point of back 2·5; from shoulder to shoulder 2·4; diameter of opening in the back of the head from ·6 to ·7 of an inch. The very great

No. 7775.

resemblance of this figure to a small Mexican idol in the Museum (No. 1469) is very striking. The idol is carved in stone and represents a woman in this same squatting posture with her hands upon her knees. See also the figure of a man in this same posture in Foster's Prehistoric Races of the United States, p. 240. This last represents a water jar of the same general character as 7775 and is also from a mound in Missouri.

No. 7841. A large pipe carved from a hard sandstone and rudely representing a frog or a toad. The design is better seen from a side view than from the front as represented by the woodcut. The block of stone composing this pipe bowl weighs 3 pounds and 9 ounces, and is 5·5 inches in length, 3·7 in width and 3·9 in height. The head of the toad, or the part projecting from the front of the block, is 1·5 inches, the width of its mouth is 1·7, and the distance from the outside of one eye to the other is 1·2 inches. The diameters of the bowl of the pipe and of the hole for the stem are each 1·3 inches, and the two holes are equal in depth, 2 inches. The holes rapidly narrow as they extend inwards, being but ·2 of an inch in diameter at their union. The hole for the stem is symmetrical throughout, but

No. 7841.

that of the bowl is slanting on its front and nearly vertical on its posterior portion.

No. 7761. This is the vessel which Prof. Swallow states was found "near the side of the mound, bottom up and containing a human skull and one vertebra." It is rather rudely made and is

No. 7761.

not so smooth on its surface as the figure represents. There is very little mixture of other substances with the clay of which it is composed. A small portion broken out near the bottom shows it to be about ·4 of an inch thick, and also that the pot has been hardened by fire, both on the inside and the outside. As shown in the cut, it is provided with four handles symmetrically placed. It is 5 inches high, 6·3 to 6·5 in its greatest diameter and 4·6 to 4·8 inches across the mouth.

No. 7773

Nos. 7773 and 7764 are two pots very similar to the one last described. The largest of these, No. 7773, is 6 inches high, and

from 7·7 to 8 inches in diameter. The opening is 5·8 to 6·3 in diameter. The other is much thicker, and is about 5 inches high, by 6·8 in diameter.

Nos. 7820 and 7824, represented in the cuts of about one-

No. 7820.

No. 7824.

quarter their natural size, are probably handles broken from vases similar to those taken from another mound and here figured as No. 7717.

No. 7842 is probably a natural flint concretion that has been slightly worked over to form a small dish. Its shape is best seen by tipping the engraving over to the right. Its length is 4·4, width 3, and height 1·5 inches.

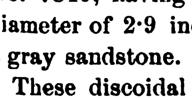
No. 7842.

No. 7843 is a small discoidal stone of diorite, quite smooth and polished. It is slightly concave on its upper surface, with flat bottom and vertical sides, and is 1·2 inches in diameter by ·5 of an inch in thickness.

No. 7843.

No. 7838. A double concave disk of sienite, 2·8 inches in diameter by 1·1 in thickness. The concavities are not over ·2 of an inch in their greatest depth. The sides of the stone are rounded. No. 7839 is another of these stones of the same shape, except that the sides are a little more rounded. This stone is slightly polished, perhaps by use. It is of the same thickness as the first mentioned but is ·6 of an inch less in diameter. With these is another discoidal stone, No. 7840, having a thickness through its centre of 1·4 and a diameter of 2·9 inches, but double convex in shape and made of a gray sandstone.

No. 7838.



These discoidal stones of various forms and sizes are very interesting relics, and as we know that such stones were used in games by the American Indians, especially by the Southern tribes and by the Mandans as described by Adair, Finly, Bartram, Catlin, and others, it is very probable that these stones wherever

found were used for similar purposes. Messrs. Squier and Davis, in "Ancient Monuments of the Miss. Valley," figure a number found in mounds and on the surface, and call attention to their enigmatical character and to the fact that they have been found from Ohio to Peru, and also in Denmark. So far as their observations go, they regard those found in the mounds as, probably, of more recent origin than the mounds, but those found by Prof. Swallow in the "Big mound" are evidently of the same age as the other articles in the collection, and the very large number from the Mounds in Tennessee, collected by Mr. Dunning and now in the museum, would indicate that they belong to the mound period as well as to later times. It is interesting in this connection to record two of these stones found in Hartford, Connecticut, by the Rev. E. C. Bolles, and now in the Peabody Academy of Science at Salem, and also to refer to the specimens in the Museum from the Hawaiian Islands, one of which, No. 2903, is labelled "Stone used in the *game of maika*, Hawaiian Islands." The game played with such stones by the Mandans is called "Tchung-kee," which Adair gives as "Chungke." From these names and the term "Chunky-yard," used by Bartram in his description of the peculiar enclosure in the Creek villages in which the game was played, these stones are now generally called "Chunky-stones," but it is questionable if this name should be given to any except those of large size which are perforated, as the game described by Catlin requires a "ring of stone" so that if the pole is well thrown the ring will fall upon one of the projecting points on the pole. That those not perforated may also have been used for some other game is probable from the fact that the stones used by the Hawaiians in their game of "maika" are, to judge from the several specimens in the museum, simple biconcave and biconvex disks, in every respect like those found in America. It is also very probable that some of the smaller stones of this character were used as paint rubbers, for it is evident that some such articles were required if paint were used.

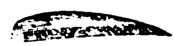
No. 7874.

No. 7873.

Nos. 7873 and 7874 are two articles carved from a hard clay slate and carefully smoothed. Their use is problematical, but they so closely resemble lip ornaments as to suggest that they were such. The largest measures 1·2 inches in length by ·7 across the top; the other is ·9 of an inch in length by ·6 in greatest diameter.

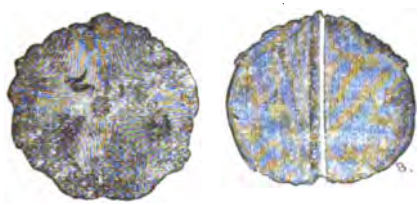
No. 7875 is a needle made of the point of a deer's antler. The larger end has been perforated by a small hole and is broken at this point. The woodcut does not give a very good idea of the specimen which is 3·3 inches long and ·5 of an inch in diameter at its large end. A similar needle, made of a deer's horn, was found by Stevens with a skeleton in an ancient burial place in Yucatan, and he states that the Indians of that country still use the same kind of needles. There is also an awl, 4·5 inches in length, which probably came from the Big mound, though it is not specially mentioned by Prof. Swallow. This awl is like those figured by Squier and Davis from mounds in Ohio, and is made from a bone of a deer.

No. 7875.



Nos. 7858, 7864 and 7865 are several masses of clay used as plaster on the chamber of the mound as described by Prof. Swallow, and several of the pieces show the impressions of the reeds over which the clay was spread. No. 7866 is a rough ball of burnt clay about 3·5 inches in diameter, and shows the impression of the skin and finger marks of the hands that moulded it. This mass was perforated through the centre as shown in the figure giving a section.

No. 7866.



No. 7855 is a large hoe, beautifully chipped from a piece of brown flint. It is 11·3 inches in length, 5·1 in greatest width, and 1·1 in thickness through the centre. One of the surfaces is nearly flat and is much polished by wear on its lower third, while the opposite surface is slightly convex and only polished by wear along its lower edges.

No. 7834 is a polished celt of greenstone, worked in the form of a broad chisel. Its flat surface represented in the figure is 2·4 inches in greatest width and 4·7 from the rounded upper end to

the beginning of the bevelled edge, which is ·9 of an inch deep. The cutting edge is made by the grinding down of this side *only*.

No. 7852.

No. 7855.

No. 7834.

The opposite surface is flat along its central portion but the sides are rounded. The thickness of the stone is one inch.

No. 7852. This is a beautiful, little chisel of orange flint, polished on its two broad surfaces but with its sides left roughly chipped. The greatest width of the implement is across its cutting edge, which is made by grinding from both surfaces. Length 3·5, thickness ·7, width 1·4 inches.

Nos. 7853 and 7854 are two chipped flint chisels, long and nar-

No. 7853.

No. 7854.

row, and polished only at the cutting portion. The cutting edge is made by grinding from both surfaces. The cuts do not accurately represent these implements, which are chipped nearly flat on one surface and roughly convex on the opposite. They are of the same general shape, though of considerable difference in size.

The largest, which is made of a gray flint, is 7·6 inches in length, 1·5 in width across the centre and ·7 along the edge. The other is of a much lighter colored flint, and is 5 inches in length, ·7 of an inch in thickness, 1·1 in width, and has a cutting edge of ·6 of an inch.

There are also a number of other stone implements in the collection, some of which probably came from the mounds, and others were found on the surface. They are all from Missouri, and are as follows. Three thin triangular implements, No. 7844, about 4 inches in length, 3 in width and from ·4 to ·5 in thickness. These three implements would be classed either as small hatchets or skin scrapers. No. 7845 is a spear head, 3·9 long by 1·8 wide. No. 7846 is a finely chipped knife, 4·9 long by 1·5 wide. This implement would generally be classed as a spear head, but its finely chipped edges and long delicate shape rather indicate its having been mounted in a short handle for use as a knife[1]. No. 7847 is probably another knife, of the general shape of the preceding, but smaller, and having two notches probably to aid in securing it to the handle. This knife is 3·6 long by 1·4 of an inch wide. No. 7848 includes four arrowpoints of common form and size. No. 7849 is probably a small spearpoint 3 inches in total length by 1·5 in width. No. 7850 is a short and broad arrowhead, with long wings or barbs and obtusely pointed. This is 1·7 in total length by 2·5 in width across the barbs. No. 7851 is a boring tool, 2·5 inches long by about ·3 to ·4 of an inch in diameter, with a short but, about 1·2 inches wide. All the above mentioned implements are made from white or slightly yellow colored flint, and show perfection of workmanship.

There are seven stone axes of ordinary size; the smallest of these being 5 inches in length by 2·8 in width; the largest is 7·8 long by 4·8 inches in width. Nos. 7827, 7830 and 7831 are of sienite, and are grooved on three sides, the fourth side being squared. In 7827 the groove passes a little to the squared or handle side, and this axe also has a more rounded cutting edge than the others. No. 7828, the largest of the lot, is of green stone and the lower part of the axe is more narrowed than in the others. No 7830 differs from the others in having a flat top, like the iron axe of the present time, and more nearly resembles

[1]There are, in the Museum, several flint knives from Europe which are very similar to this implement from Missouri, Nos. 859 and 865, from Rügen, are very close indeed as regards material, size, shape and finish of workmanship.

it in its general shape than do the others. No. 7832 is an axe of sienite, but differs from the preceding in having the groove carried all round. It is 5·7 long by 3·4 wide and 2·2 in thickness. No. 7829 is a finely carved, grooved axe, made of clay slate. The top is flat and the surface, which came in contact with the handle, is slightly concave, and the groove, which is quite deep on the opposite side, fades out gradually as it approaches this side. The front of the axe is also slightly concave, and at the same time has a curved outline from its top to its cutting edge, which is short and rounded. This axe, which is beautiful from its perfect symmetry and finish, is 6 inches in length 3·5 in greatest width just below the groove, and 2·5 in thickness. The groove is from ·8 to ·9 of an inch in width. The cutting edge is 2·5 in length. No. 7833, which is specially marked as having been found on the surface in Boone Co., is of a very unusual shape and may possibly be an unfinished implement. It is of sienite, 7·1 inches long, 3·7 wide across its upper third, 2·4 along its cutting edge, its greatest thickness 2·5. The top of the axe is flat; sides bulging; front and back edges grooved and convex in outline, the front of the axe being the most arched.

Nos. 7835 and 7836 are two hatchet-shaped implements of sienite. They are partially polished, about 4 inches long and 2·5 wide, and of the usual form of these small, or hand celts, as they are often called.

No. 7861 is a small implement of sandstone, of about the size of the last, but more triangular and with a deep groove, as if for the ball of the thumb in holding the implement in the hand.

No. 7837 is a small block of mottled greenstone such as many articles of ornament are made of. This block is 2·8 inches by 3·3, and 1·2 in thickness through the middle. It has the general appearance of a block roughly put in shape for the final purpose of making a "gorget."

Nos. 7856, 7857, and 7859 are pieces of sandstone evidently used for sharpening implements. 7859 has a number of grooves occasioned by use.

No. 7763 is a portion of the shell of *Busycon* from a small mound in New Madrid Co.

I quote from Prof. Swallow's manuscript the following account of two other mounds opened by him, and from one of which the rest of the articles here described were obtained.

"A smaller mound, 418 feet east of the south end of the Big Mound, was examined. This mound was nearly circular, 360 feet in circumference, 14 feet high, 8 feet above the present surface of the country, as 6 feet of stratified sands and clays have been deposited on the bottom since the mound was formed. In this mound were found ashes, shells, charcoal, fragments of bones and pots. Nothing of any great value.

"In Township 23, Range 15 East and Sec. 26, and about 6 miles E. N. E. of New Madrid, we opened a small mound, from which we obtained all the articles sent which are not otherwise designated. It was overgrown with trees and had not been disturbed, save in a small place on one side. This mound was circular in form.

"The pots and jars were found in a circle near the circumference, or perhaps two-thirds of the distance from the centre of the mound to the outer edge, and on the original ground beneath the mound. We found the base of the mound, when the earth was carefully removed, discolored with dark stains on the earth in the shape of a human body, with head to the pot and the feet towards the centre of the mound; also, the position of the skeleton was marked by traces of whitish, calcareous earth. We also found some fragments of the enamel of teeth just within the line of the pots where the form of the head was shown. These bodies seemed to have been placed as closely together as possible, and a pot or jar at the head of each. So regularly were they arranged that we could find them by following up the circle after we had discovered the key. There seemed to be pots in no other position in the mound. All found were in this circle.

"It appeared as if the bodies had been placed in position, and the pots and jars in their places, and then the mound built over them. In the middle of the mound we found with the earth, ashes, coal, fragments of shells (*Unionidæ*) and broken pottery. I found one *Fusus* near one of the jars in the circle.

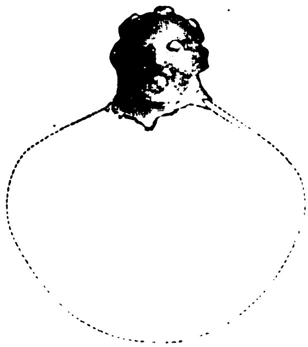
"Everything in this mound was greatly decomposed by time and the elements, save the pots and jars of the best quality. Other pots fell to pieces as soon as they were disturbed. They have become much firmer since they were taken out.

"The best pots are made of blue clay, fine sand, and pounded shells, which materials exist in the neighborhood."

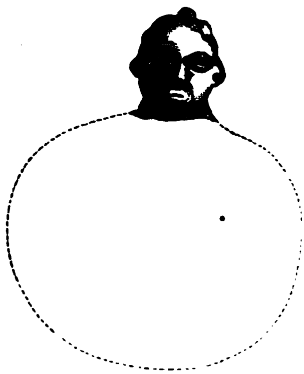
Nos. 7747, 7748, 7750, 7751 are figures of the human head in clay, and once surmounted jars like No. 7782, but of larger size. Prof. Swallow states that the jars were all broken, and the restorations,

indicated by outlines in the three woodcuts, are as correct as the fragments would permit. 7745 and 7748 are the two heads showing the most finished workmanship, and agree with 7747, and also with 7782, in having the hair or a head dress represented as an

No. 7747.

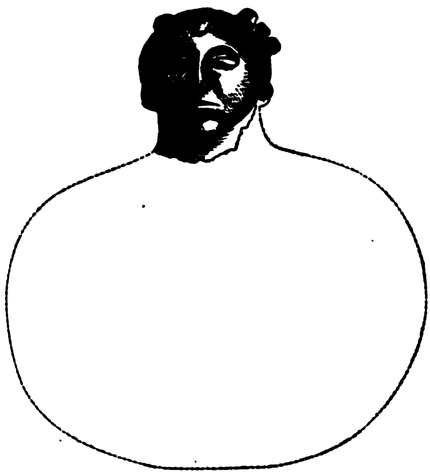


No. 7750.



ornamented band over the top of the head. 7782 and 7747 have this band represented after the same pattern, or with a central and two side projections or bunches. 7748 has a large bunch on the left side and a smaller and circular one on the right, while the

No. 7748.



centre of the band is brought over the forehead. In this head the ears are perforated, while in all the others they are not placed quite so low down and stand out prominently from the head. In 7750

the head dress represented is evidently of a more elaborate pattern than in any of the others, and looks as if the hair had been arranged in five folds of which the central one was much the largest. There is also a certain indescribable appearance to this head which gives the impression that it represents that of a man, while all the others have a feminine appearance. All the heads but 7747 have the eyes and mouth represented with distinct lids and lips, but in 7747 the bunch of clay forming the mouth has not been cut to show the lips, and that forming the left eye is also a simple round bunch placed in a depression representing the eye socket, while the bunch representing the right eye was omitted or has since fallen off. No. 7751 has the top of the head smooth, as if the individual represented had been without the usual head dress.

The following measurements will give the size and proportions of these faces.

No.	Width of face, not including the projecting part of the ears, in inches.	Distance from top of head to chin, not including the projecting part of the head dress, in inches.	Distance from root of nose to the chin, in inches.
7747	2	2·1	1·3
7748	2·15	2·2	1·5
7750	2·1	1·9	1·1
7751	2·4	2·4	1·6
7782	1·1	1·2	1·7

No. 7782 is a perfect jar with the head surmounting it and having the opening behind. This was evidently the smallest of the several jars of this character found in the mound, and is made of the blue clay, slightly mixed with sand, as are the majority of the articles of pottery found in this mound. The measurements of the face are given above. The body of the jar is spherical and with hardly any perceptible flattening below. The diameter at its largest part is from 4·5 to 4·6 inches, and the total height is 5·6 inches. The opening in the back of the head is about ·8 of an inch in diameter.

No. 7782.

The seven following cuts represent others of this very interest-

ing series of vessels with necks and heads and with the circular opening behind.

No. 7786 is 7·4 in diameter and 7·5 inches in total height.

No. 7786.

No. 7783.

The width of the odd looking face, which may have been intended to represent that of an owl, is 2·3 inches; the "bill," or part between the eyes, projects half an inch. The apertures of these several jars are nearly of the same size, varying from about 1·3 to 1·7 inches in diameter.

No. 7783 was perhaps intended to represent some animal with projecting ears. The cuts show these ears and the opening in the back of the head. This jar is 6·1 inches in greatest diameter and 8·2 inches high.

The heads on Nos. 7781 and 7785 have the appearance of being

No. 7781.

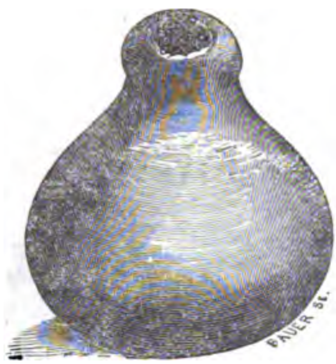
No. 7785.

left in the first stages of the design that they were to exhibit. The larger of these jars is 7·5 inches in diameter by 8·5 in height. The smaller is 4·8 in diameter by 5·6 inches in height.

No. 7784 has the appearance of the opening being in the front of the head, which is much pointed, as if the hair had been carried to a point above and dropped down the back of the neck in the form of a queue with two knots. The appearance of a high

No. 7784.

No. 7745.



forehead with a prominent nose and chin, which the woodcut gives, is not so apparent on examining the specimen, as the artist did not properly represent the narrowness of the projecting band by showing the neck upon which it rests. The height of this jar is 9 inches and its greatest diameter is 7·7 inches.

No. 7745 is one of these neck and head jars, of about the same size as 7785, but has the head part reduced to a simple spherical top without any attempt to form features.

No. 7774 is a jar of the general character of the preceding, but differs from them in being colored red, and in the whole jar being made to represent the form of a bird at rest, perhaps that of the horned owl. A front view shows the feet and projecting part of the folded wings, the large eyes, projecting feathers or "horns" of the head, and the bill, which has been broken off as shown in the cut. A back view represents the back of the head, with the aperture of the jar, the wings folded on the sides, and the pointed

tail, on which, with the legs in front, the jar firmly stands. The size of this very interesting vessel is 10 inches in height, 7 inches in diameter from wing to wing, and 6·7 inches in diameter from front to back.

No. 7774.

Col. Foster, in his Prehistoric Races of the United States, describes and figures two vessels of the same character as those mentioned above. On page 239 of his work he represents one from a mound near Belmont, Missouri, which in design is very close to those here figured as Nos. 7747, 7748 and 7750. The most interesting of his figures, however, in this connection, is that on page 243 of a "water jug found near the mouth of the Wabash." This figure shows the jar to be of the same rude design as Nos. 7783 and 7786 of the Swallow collection, and must be considered as having been made by the same people, though there is no indication of its having been found in a mound.—[*To be concluded.*

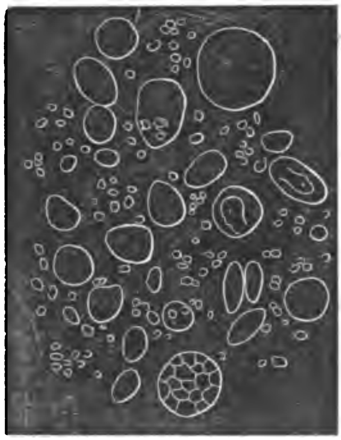
ABOUT STARCH.

BY PROFESSOR M. W. HARRINGTON.

II.

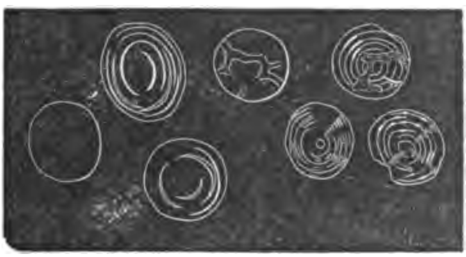
We have seen, in a former paper, that potato-starch consists of organized grains, each with a nucleus and around it a series of layers, each of which is denser than the one next within. This is the typical form of the grains of starch, but there are many variations on it. Many grains are without rings or nucleus or both. Sometimes the rings and nucleus can be brought out in these, by the action of reagents or by partial solution in any way. This is illustrated in the grains of wheat-starch. In Fig. 151 (taken from Planchon) we have the usual appearance of the starch of wheat. The largest grain at the bottom of the cut is a compound grain rare in wheat, characteristic of the starch of another group of cereals. In the typical grains we see no rings, only occasional incidental markings. In

Fig. 151.



Wheat Starch.

Fig. 152.



Wheat Starch.

Fig. 152 (also from Planchon), we have wheat starch after the grain from which it was taken has germinated and solution has begun. In the starch-grains of many species, however, no rings can be

made out, even with the aid of reagents. An illustration of this is the starch from the Colchicum-corm of the druggists (Fig. 153). Here we have a nucleus, often split into stellate shapes by drying, but no rings. Rings are not brought out by reagents, nor is there any cross with polarized light. In Fig. 154, which illustrates the starch of the root of aconite, we find neither nucleus nor rings.

Fig. 153.

Colchicum Starch.

Starch is nourishment for the plant in a condition for preservation. We consequently find it in the thickened parts of plants, which serve as storehouses of nourishment. The starch of potato is in the tuber, a sort of thickened tip of an underground branch. In the colchicum the starch is in the corm or thickened base of the stem; in squills it is in the bulb. Rhizomes usually contain starch. That of the white water-lily is large and easily examined. The starch of the ginger rhizome is quite characteristic. That of the rhizome of sweet flag is very minute; the largest grains are hardly $\frac{1}{4000}$ of an inch in diameter. The slender rhizomes of the gold-thread contain a starch which is larger. The root often contains a large quantity of starch. The root of Stillingia of the shops is almost made up of starch. The stem of the sago-palms contains starch in immense quantities. The sago of commerce is derived from several species of them. Most barks of trees contain starch; though often in small quantities, sometimes the amount of starch is considerable in barks. Cinnamon contains a great deal. The starch may be confined to one layer of the bark, or, more abundant in one layer than in the others. In cascarilla bark, where the middle layer of the bark and the liber interdigitate, it is difficult to trace

Fig. 154.

Aconite Starch.

out the line of division between the two until iodine is added. The middle layer contains much starch, the liber little. When the iodine is added the starch turns dark and the middle layer looks like a distinct black saw, with teeth projecting into the liber. In many fruits and seeds starch is found; in the embryo of the bean and pea and in the albumen of the nutmeg, corn, wheat and rice, it is very abundant.

The strangest situation, though, in which the writer ever found starch was in the centre of a nut-gall. In the middle of the hard commercial galls (obtained from *Quercus lusitanica* Webb, var. *infectoria*, from Asia Minor), is a little, hard, nut-like case of thick-walled, stony cells. This case is filled with cellular matter when first formed. The larva of the infesting insect is found within this case, and feeds on its cellular contents. If the gall is collected when the insect has already escaped, this little nut-like sphere is empty. If the gall is picked when immature, there is some matter left in the central nut, the greater or less quantity depending on the immaturity of the gall and of the enclosed insect. This matter within the central case, on which the insect feeds, contains starch. None of the rest of the gall-tissue contains the slightest trace of it. The grains (Fig. 155) are large and flat with a distinct nucleus, and, usually, distinct rings. They produce a marked cross with polarized light. They are so large that a cell seems to accommodate only a single grain of starch.

Fig. 155.

Starch of Nut Galls.

The presence of starch in this abnormal growth suggests some interesting questions. The starch is just where the parasitic *Cynips* will eat it and nowhere else. Starch is excellent food for many animals. We eat immense amounts of it with our cereals. The sparrows live on it. Doubtless the larva of the gall-fly finds it good food. On what principle of natural selection can we account for this food being placed so conveniently for it? So far

as we can see, the *Cynips* does nothing but injury to the oak. Why should the oak provide it with choice food?

So far we have had in mind only vegetable starch. At one time it was thought that starch was peculiar to vegetables, but it has since been found in animals. In so undoubted an animal as man, starch has been found in organized granules in the brain. In appearance these grains of cerebral starch are very much like those of corn-starch. They are, however, softer.

Starch is usually found in the parenchymatous tissue of plants. Exceptionally it occurs in the elongated, tapering cells. Pocklington records in the "London Pharmaceutical Journal," the constant occurrence of starch in the wood-cells of the ipecac root of the shops. A matter analogous to starch is found as secondary layers on the cell-walls of some seeds. Schleiden calls it *Amyloid*, and gives a short list of seeds in which he has found it. A probably identical substance is found in the seeds of the common peony. The peony seeds but meagrely here, but the seeds are used somewhat in medicine, and can be found in many shops, where they have been imported from Europe. The albumen of the seeds is made up of a compact parenchyma, with moderately thick-walled cells, filled with a granular matter. On the application of a weak solution of iodine, the contents of the cells are colored a bright yellow, but the cell-walls a pure blue. If they were of cellulose, the ordinary constituent of the cell-walls, they would not be colored blue by iodine until after the action of sulphuric acid.

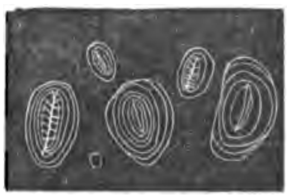
Starch-grains are developed by gradual growth. The different stages can be seen in most starches, from the matured parts of plants. It can be seen still better in a nearly ripe grain of corn. Every stage of the following process can be seen there. A little cavity or vacuole is formed in the protoplasmic contents of a vitally active cell. A little matter is there deposited, and becomes the nucleus. The cavity enlarges, and a layer is deposited around that already formed. Layer after layer is laid on until the grain attains a full size. This process has been watched by several observers in the fronds of *Hepaticæ*. Crüger, as quoted in the Micrographic Dictionary, says that the unsymmetrical forms of many grains is owing to the differing density of the protoplasm in which they are formed. The thicker part of a grain of potato-starch, for instance, is formed in the thicker protoplasm, while the

extended, thinner part is pushed out to where the protoplasm is less dense. It is often said that starch is especially formed in the presence of chlorophyl or the green coloring matter of plants. But we notice that it is generally deposited where there is no chlorophyl, as in the roots, underground stems, the albumen of seeds, etc. Starch is formed in protoplasm, whether there is chlorophyl present or not. When the latter is present, its tendency to collect around the solid matters of the cell, the walls, for instance, will lead it to collect about the forming starch-grain, and thus give that grain the appearance of being embedded in chlorophyl, an appearance often noted.

The form and appearance of the grains differ for each species. In nearly allied species they are much alike; in distant species, very different. Whether in all or most cases specific characters can be drawn from the grains is not fairly settled. It has never been systematically studied, so far as I know. In a few limited cases it has been done and with success. From these it is a fair presumption that specific differences in the grains exist, but are hard to recognize on account of their minuteness.

The size varies much but is tolerably constant for the same species in mature grains. The smallest measured by the writer were only 2 tt.[1] in length. They were from the rhizome of *Hydrastis Canadensis* L. Those measured were the largest grains. On the other hand the grains of potato-starch sometimes reach a length of nearly 50 tt. They are then so large that they can be distinguished by the naked eye. The grains of canna-starch are said to be even larger.

Fig. 156.



Bean Starch.

The commonest starches of commerce are the following. The figures are from Vogl.

1. *Bean-starch* (Fig. 156). The grains are in the cotyledons. They are packed in very closely with aleurone. They are of an ellipsoid or reniform shape, and are 30 tt. or less in length. The rings are usually not visible, though sometimes very evident. The nucleus is long and slit-shaped. In two of the grains figured, smaller cracks can be seen. They are caused by heating. They are easily seen by making a thin section of a bean or by simply

[1] tt = ten thousandths of an inch.

scraping off in a powder a small portion of the cotyledons. They derive their interest, not from their use in the form of starch as food, but because they have formed — or some of the closely allied starches — several almost historical quack medicines, and because they are yet frequently used in Europe to adulterate powdered medicines. The writer has found, in this country, specimens of pearl sago entirely made up of bean or pea-starch.

2. *Potato-starch* has been already figured and partly described. It derives its special interest from its universal use to adulterate powders. Commercial arrowroot, not the proprietary, is, to a considerable extent, made up of potato-starch in this country.

3. *Tapioca* (Fig. 157) is the starch of the root of *Manihot utilissima*, a poisonous Euphorbiaceous plant. The starches of some other closely related species are sometimes intermixed. The grains are small, less than 10 tt. long, shaped like a hemisphere somewhat drawn-out. Viewed from the end the grain and nucleus appear round; seen from the side, the grain appears arched, and the nucleus seems to have a conical hollow space extending from it to the base of the arch. In the original condition the grains probably have the truncate ends set together, thus forming compound grains with two individuals in each.

Fig. 157.

Tapioca Starch.

In commerce, tapioca is in irregularly agglomerated masses of small size and a dead white color. These are formed by heating the grains when wet on hot plates. Sometimes the heat affects the appearance of the starch-grain, swelling it and causing it to bulge out in one or more places.

Fig. 158.

Sago Starch.

4. *Sago* (Fig. 158) is from the stem of, probably, several species of palm-trees belonging to the genera *Sagus* and *Saguerus*. It is composed of muller-shaped grains, which are rarely more than 25 tt. long.

In its original state the starch-grains are compound, consisting of one large grain with one or two quite small ones fastened to it. The component grains are separated in the preparation and we find the small ones scattered among the large. The nucleus

of the largest grains is dot-like, eccentric and usually quite distinct. The rings are not very apparent.

Sago, in American commerce, appears in two forms; common or brown sago, by far the most common, is found in the grocery and drug-stores in small roundish brown masses. They are little altered by heat and the grains present the characters just described.

The pearl sago is in larger spherical balls, of a dead white color. It has been subjected to heat and the grains are smaller and their nuclei are bulged out.

5. *Wheat-starch* consists of disk-shaped grains 16 tt. or less in diameter, mixed with numerous minute spherical grains. The nucleus and rings are usually not visible. Wheat-starch is now not common here as a commercial starch. In medicine and the arts it is nearly replaced by corn-starch.

Fig. 159.

Corn Starch.

6. *Corn-starch* is derived from the albumen of the grain of Indian corn. The grains (Fig. 159) are small, from 5 to 10 tt. in diameter, of an irregular form. The surface consists of partly convex, partly flat faces, the latter being formed by mutual pressure of the grains. The nucleus is star-shaped, at least when dry. There are no rings.

Corn-starch now replaces the most of the other starches, under its own name or that of maizena, maizone, etc. The *amylum* of the Pharmacopœia which calls for wheat-starch is, in every one of the many samples examined by the writer, corn-starch. As the latter is certainly as palatable as wheat-starch, and is probably more nutritious, we cannot object to the substitution except on the principle that every craft should sail under its own colors.

Fig. 160.

Arrowroot.

7. *Maranta or Arrowroot* is a name applied to a great many starches, the sort being designated by another term, as Brazilian arrowroot, referring to the tapioca-starch when in a powder. West India or Bermuda arrowroot is

the common sort in the United States. It is derived from the rhizome or underground stem of Maranta. It consists of grains (Fig. 161) with a length of 24 tt. or less. They are ellipsoid or egg-shaped with the nucleus in the centre or toward the larger end. By this character it is at once distinguished from Potato-starch, which it otherwise resembles.

The rings are easily seen, though fine. West India Maranta is often adulterated. The starches which are used to falsify it can be detected with certainty only by the microscope.

BOTANICAL OBSERVATIONS IN SOUTHERN UTAH.

BY DR. C. C. PARRY.

No. 5.

No. 143. *Nemacladus ramosissimus* Nutt. Torrey, Bot. Mex. Bound., p. 108, t. 14.

No. 144. *Utricularia vulgaris* L. Cedar City. July.

No. 145. *Phelipæa Ludoviciana* Walp.

No. 146. *Antirrhinum Cooperi* Gray. Proc. Am. Acad., vol. vii, p. 376. A slender twining plant, likely to be overlooked, collected by Dr. Cooper on the Lower Colorado in 1861; also by C. A. Almendinger in 1868; found sparingly near St. George in the shade of high basaltic cliffs. May.

No. 147. *Eunanus* ——? A slender, large flowered, showy annual, growing abundantly on gravelly hills near St. George; flowers mostly bright yellow. A light pink variety (?) was also met with later in the season.

——. *Mimulus rubellus* Gray.

No. 148. *Pentstemon ambiguus* Torrey. Marcy's Rep., t. 16. Dry sandy soil in the upper valley of the Virgen. June.

No. 149. *Pentstemon Eatoni* Gray. Proc. Am. Acad., vol. viii, p. 395. Common in all rocky gorges near St. George; also cultivated in gardens.

No. 150. *Pentstemon glaber* Pursh, var. Cedar City. July.

No. 151. *Pentstemon cæspitosus* Gray, var. Cedar City. July.

No. 152. *Pentstemon puniceus* Gray, var. *Parryi* (?). Beaver-dam mountains. May.

No. 153. *Castilleia parviflora* Bong.

No. 154. *Castilleia affinis* H. & A.

No. 155. *Cordylanthus* (*Hemistegia*) *Parryi*, n. sp. Closely resembling *C. canescens*, from which it is distinguished by its scattered greenish-yellow flowers, the bracts exceeding the calyx and corolla, the narrow erect teeth of the calyx, the tube of the corolla much shorter than the throat, and by the shorter filaments sparsely hairy. *C. canescens* has purple flowers in crowded heads, the bracts equalling the calyx and corolla, the teeth of the calyx short and spreading, the corolla-tube as long as the throat, and all the filaments naked.— Saline marshes in the valley of the Virgen. June. — S. WATSON.

No. 156. *Cordylanthus Kingii* Watson. King's Rep., p. 233, t. 22. High mountains east of Cedar City. July.

No. 157. *Nicotiana attenuata* Torr. Watson, King's Rep., p. 276, t. 27. Common in all waste places near St. George. May.

No. 158. *Nicotiana trigonophylla* Dunal. Common on rocky hills near St. George. May.

No. 159. *Audibertia incana* Benth. A very showy, strong-scented, aromatic plant, growing in clumps, 1–2 feet high. May.

No. 160. *Salazaria Mexicana* Torr. Bot. Mex. Bound., p. 133, t. 39. Not uncommon on rocky slopes adjoining the Virgen, from whence the first imperfect specimens were collected by Fremont in 1844. Flowering in May; fruit in June.

No. 161. *Salvia Columbariæ* Benth.

No. 162. *Lophanthus urticæfolius* Benth. Cedar City. July.

No. 163. *Lithospermum angustifolium* Michx. Gray, Proc. Am. Acad., vol. x, p. 51.

No. 164. *Eritrichium micranthum* Torr. Gray, Proc. Am. Acad., vol. x, p. 58.

No. 165. *Eritrichium circumscissum*. Gray, Proc. Am. Acad., vol. x, p. 58. Beautifully figured by Torrey in Bot. Wilkes' Explor. Exped., t. 12, B.

No. 166. *Eritrichium leucophæum* A. DC. Gray, Proc. Am. Acad., vol. x, p. 61. Flowers light yellow. Beaver-dam mountains. May.

No. 167. *Pectocarya lateriflora* DC.

No. 168, 169. *Eritrichium pterocaryum* Torr. Bot. Wilkes' Explor. Exped., p. 415, t. 13, B.

No. 170. *Amsinckia tessellata* Gray. Proc. Am. Acad., vol. x, p. 54.

No. 171. *Eritrichium angustifolium* Torr. Gray, Proc. Am. Acad., vol. x, p. 59.

No. 172. *Echinospermum deflexum* Lehm., var. *floribundum*. Hook. Fl. Bor.-Am., vol. ii, p. 84, t. 164. Pine valley. June.

No. 173. *Eritrichium glomeratum* DC., var. *humile* Gray. Proc. Am. Acad., vol. x, p. 61.

No. 174. *Hydrophyllum occidentale*. var. *Watsoni* Gray. Proc. Am. Acad., vol. x, p. 316. High mountains east of Cedar City. July.

No. 175. *Emmenanthe penduliflora* Benth. Upper Santa Clara valley. June.

No. 176. *Phacelia integrifolia* Torr. Gray, Proc. Am. Acad., vol. x, p. 318. Gypseous clay soil in the valley of the Virgen. May.

No. 177. *Phacelia Fremontii* Torr. One of the earliest and most showy spring flowers. March to May.

No. 178. *Phacelia Ivesiana* Torr Inconspicuous white flowers. St. George. April.

No. 179. *Phacelia (Eutoca) cephalotes* n. sp. Gray, Proc. Am. Acad., vol. x, p. 325. On bare clay soil in the valley of the Virgen. May.

No. 180. *Phacelia crenulata* Torr. Gray, Proc. Am. Acad., vol. x, p. 318. Exposed rocky and gravelly slopes. St. George. May.

No. 181. *Phacelia micrantha* Torr. Bot. Mex. Bound., p. 144. Gray, Proc. Am. Acad., vol. x, p. 327. Crevices of basaltic rocks. April.

No. 182. *Phacelia pulchella* n. sp. Gray, Proc. Am. Acad., vol. x, p. 326. Abundant on gypseous clay hills near St. George. May.

No. 183. *Phacelia rotundifolia* Torr. In shaded crevices of perpendicular rocks. St. George. May.

No. 184. *Phacelia ramosissima* Dougl. Gray, Proc. Am. Acad., vol. x p. 319. Dry bushy plains, subscandent on low shrubs. May.

No. 185. *Nama demissa* Gray. Proc. Am. Acad., vol. viii, p. 283. A low annual, with copious red flowers set on the prostrate branches; abundant on gravelly slopes near St. George. May.

———. *Tricardia Watsoni* Torr. Watson, King's Rep., p. 258, t. 24. Only a single specimen of this interesting plant was found on the south bank of the Virgen. April.

No. 186. *Phlox canescens* Torr. & Gray. The common tufted Phlox of this region.

No. 187. *Gilia filiformis* Parry, n. sp. Gray, Proc. Am. Acad., vol. x, p. 75. Rocky slopes near St. George, April. A very delicate species, resembling in flowers and foliage some of the slender forms of *Linum*.

No. 188. *Gilia latifolia* n. sp. Annual, viscid with spreading glandular hairs, erect, 4–6 inches high, branching only above; leaves few, broadly ovate, 1–1¼ inches long, rounded at the apex, narrowed below into the usually slender petiole, coarsely sinuately dentate with spinose teeth; flowers scattered in a loose panicle; bracts setaceous; calyx 2½ lines long, cleft nearly to the middle with setosely acuminate lobes;

corolla short funnel form, 3 lines long, light pink, the acute lobes half as long as the tube; filaments included, inserted below the middle of the tube; capsule oblong, many-seeded; seed not mucilaginous. — Of peculiar habit, to be included in the section *Eugilia*, but not approaching closely any of the other species. — S. WATSON.

No. 189. *Gilia Bigelovii* Gray. Proc. Am. Acad., vol. viii, p. 265. Watson, King's Rep., p. 263, t. 15, f. 3.

No. 190. *Gilia setosissima* Gray, l. c., p. 271. A very neat and ornamental species, abundant on rocky slopes near St. George. May.

No. 191. *Gilia polycladon* Torr. Bot. Mex. Bound., p. 146. Gray, l. c., p. 274.

No. 192. *Gilia floccosa*, var. Gray, l. c., p. 272.

No. 193. *Gilia congesta* Hook., var. *crebrifolia* Gray, l. c., p. 274.

No. 194. *Gilia aggregata* Spreng., var. *Bridgesii* Gray, l. c., p. 276. Pine valley. June.

No. 195. *Gilia filifolia* Nutt. Gray, l. c., p. 272. Upper Santa Clara. June.

No. 196. *Gilia demissa* Gray, l. c., p. 273.

No. 197. *Gilia leptomeria* Gray, l. c., p. 278. Watson, King's Rep., p. 270, t. 26, fig. 6–11.

No. 198. *Gilia inconspicua* Dougl. Gray, l. c., p. 278.

No. 199. *Gilia inconspicua*, var. (?). Apparently distinct from the above form. Rocky slopes, St. George. April.

No. 200. *Polemonium humile* Willd., var. Pine valley. June.

No. 201. *Lycium Andersoni* Gray. Common on rocky hills near St. George; distinguished from the following by its copious slender flowers and general habit; flowering in April; fruit in June. The bright red or amber colored berries are edible.

No. 202. *Lycium Torreyi* Gray. Low saline flats of the Virgen. With larger flowers than the former; 3 to 6 feet in height; fruit red, not edible. Flowering in May; fruit in July.

No. 203. *Frasera albo-marginata* Watson. King's Rep., p. 280.

No. 204. *Cressa Cretica* L., var. DC. Prodr., vol. ix, p. 140.

No. 205. *Cuscuta denticulata* n. sp. Stems very slender, hairlike; flowers few, in loose glomerules, on short pedicels, small (scarcely one line long), white; lobes of the deeply divided globular calyx almost orbicular, over-lapping, concave, thinly membranaceous, denticulate, covering the short campanulate (finally urceolate) tube of the corolla; lobes broadly oval, obtuse, spreading, at last reflexed, as long as the tube; scales narrow, denticulate, reaching to the base of the ovate almost sessile anthers; styles slender, as long as the conical, pointed ovary, bearing slightly thickened (scarcely capitate) stigmas; capsule covered by the withering corolla, indehiscent (?), enclosing one or two seeds. — St. George, Utah, on shrubs and herbs (Coleogyne, Biscutella) in arid soil; the first addition to our Cuscuta-flora since my synopsis was published, 16 years ago. Apparently allied to *C. applanata* Eng., of Arizona, but with much smaller flowers and an acute, not depressed ovary, different calyx, etc. — Dr. G. ENGELMANN.

No. 206. *Cuscuta Californica*, var. (?) *squamigera* Engelm. Cusc. p. 499. On *Suæda diffusa* Watson. Originally found in the same region by Remy and in Arizona by Dr. Palmer, always on saline herbs; no collector has obtained the fruit as yet. — Dr. G. ENGELMANN.

No. 207. *Asclepias leucophylla* n. sp. Erect, tall; leaves (upper) sessile with a broad cordate base, tapering to a sharp bristly point, white tomentose; umbels many flowered, alternating, lateral and terminal; pedicels a little shorter than the peduncles; calyx tomentose; corolla woolly outside; hoods as long as the short-stalked stamineal tube, slightly spreading, ovate, obtuse, rounded on the inner margin; horn from the lower part of the hood, broad, ascending, horizontally incurved over the cusps of the anthers; pollen masses lance-linear, slender, slightly curved.

Dry sandy "washes" of the Virgen River, fl. June, fruit not seen. Stem 3–5 feet high; upper leaves 3½–4 inches long, 1¼–1½ wide near the base, gradually enlarging downwards, white tomentose on both sides, becoming mottled when old. Peduncles about 1 inch, pedicels ¾ inch in length; flowers about the size of those of *A. Cornuti*, with yellowish green corolla and yellow crown This species is closely related to two other white-woolly south-western species, viz.: *A. vestita*, H. & A., and *A. eriocarpa*

Benth.; the former of which has also long-acuminate leaves, but those of the latter are oblong and obtuse at both ends; all these have a short-stalked crown, broad ovate truncate or rounded hoods, and a short broad horn.

In *A. leucophylla* the hoods are largest and fully as long as the anther-tube, rounded and not dentate at the upper inner edge; the broad falcate horizontally incurved horns originate from the base and lower half of the hood; cartilaginous margin of anthers long, obtuse-angled at base; pollen masses slender, ⅖ line or more long; pistils glabrous

In *A. eriocarpa* (Hartweg's original specimen in herb. A. Gray, Remy in Mus. Paris) the hoods are shorter than the tube, angular or forming a tooth where the upper and inner margins meet, with two distinct saccate lateral projections; the broad, falcate, horizontally incurved horns originate from the entire midrib of the hood or its upper half; cartilaginous margins of the anthers shorter, sharp-angled below; pollen masses and pistils as in the last.

In *A. vestita* (Douglas' original and Bolander's specimens in herb. A. Gray) the short hood reaches to the top of the anther-tube and has a long horizontal tooth where the upper and inner margins meet; the broad obtuse horn, incurved, but more erect and exsert than in either of the allied species, originates from the middle and lower part of the tube; cartilaginous margin of anthers short, rounded below; pollen masses only ½ line in length, broad in proportion and more curved; pistil hairy.—Dr. G. ENGELMANN.

No. 208. *Acerates decumbens* Decne. Cedar City. July.

No. 209. *Astephanus Utahensis* n. sp. Glabrous, slender, spreading stems from a thick cylindric root; linear or filiform leaves; axillary few-flowered umbels; dull yellow minute flowers; corolla deeply campanulate with sub-erect cucullate lobes with inflexed points; follicles slender, long-acuminate, smooth; seeds scaly.—Drifting sand-hills near St. George, the fleshy roots penetrating to a great depth, giving origin just below the surface to the slender branches, that twine on adjoining shrubs or swing loosely on the scorching dry sands. Flowers in May; fruit in June.

This very peculiar little Asclepiad has its nearest relatives at the Cape of Good Hope, with one or two stray species in the West Indies and South America. The whole plant is of a grayish green color, the thick cylindric root light brown; the branching stems from less than a span to over a foot in length; leaves about one inch long, ½ line wide; flowers about 1–1½ lines wide. The corolla is almost closed by the cucullate inflexed points of the lobes and is glandular papillose internally, so that here these lobes themselves assume the shape and perform the functions of the hoods of other Asclepiads, to allure and retain insects to assist in the fertilization of the pistil. The pendulous broadly oval pollen masses are only one-tenth of one line long; slender follicles 2–2½ inches long; comose seeds unusually rough by scale-like protuberances. —Dr. G. ENGELMANN.

No. 210. *Fraxinus anomala* Torr. Watson, King's Rep., p. 283. Common on hill-sides and sandstone ravines throughout Southern Utah. Flowers in April; fruit in June.

No. 211. *Mirabilis Californica* Gray. Bot. Mex. Bound., p. 173.

No. 212. *Abronia cycloptera* Gray. Am. Jour. Sci., Ser. 2, vol. xv, p. 319.

No. 213. *Selinocarpus diffusus* Gray. Bot. Mex. Bound., p. 168.

No. 214. *Atriplex Powellii* Watson. Revis. Chenop. in Proc. Am. Acad., vol. ix, p. 114. Saline marshes of the Lower Sevier valley; July.

No. 215. *Chenopodium Botrys* L. Waste places. St. George.

No. 216. *Atriplex expansa* (?) Watson, l. c., p. 116.

No. 217, 220. *Atriplex confertifolia* Watson, l. c., p. 119.

No. 218. *Suæda diffusa* (?) Watson, l. c., p. 88.

No. 219. *Atriplex Nuttallii* Watson, l. c., p. 116.

No. 221. *Atriplex canescens* James, var. *angustifolia* Watson, l. c., p. 120.

No. 222. *Grayia polygaloides* H. & A. Watson, l. c., p. 122.

No. 223, 224. *Kochia Americana* Watson, l. c., p. 93.

No. 225. *Eurotia lanata* Moquin. Watson, l. c., p. 121.

No. 226. *Parietaria debilis* Forst. On steep basaltic rocks. St. George. May.

No. 227. *Polygonum coarctatum* Dougl. DC. Prodr., vol. xiv, p. 101.

No. 228. *Oxytheca perfoliata* Torr. & Gray. Watson, King's Rep., p. 311. t. 34, fig. 1. Common on gravelly table-lands. St. George. May.

No. 229. *Pterostegia drymarioides* F. & M. Torr. & Gray. Revis. Eriog. in Proc. Am. Acad., vol. viii, p. 200. Shaded rock crevices. April.

No. 230. *Chorizanthe brevicornu* Torr. & Gray, l. c., p. 196.

No. 231. *Chorizanthe rigida* Torr. & Gray, l. c., p. 198.

No. 232. *Centrostegia Thurberi* Gray. Torr. & Gray, l. c., p. 192. Upper Santa Clara valley. June.

No. 233. *Eriogonum racemosum* Nutt. Torr. & Gray, l. c., p. 175. Lower Sevier valley. June.

No. 234. *Eriogonum fasciculatum* Benth. Torr. & Gray, l. c., p. 169. Rocky crevices. St. George. June.

No. 235. *Eriogonum angulosum* Benth. Torr. & Gray, l. c., p. 187.

No. 236. *Eriogonum inflatum* Torr. Torr. & Gray, l. c., p. 185. Rocky hills. St. George. May.

No. 237. *Eriogonum reniforme* Torr. Torr. & Gray, l c., p. 184.

No. 238. *Eriogonum Thomasii* Torr. Torr. & Gray, l. c., p. 184. Forming large patches on exsiccated alluvial soil, in the valley of the Virgen. May.

No. 239. *Eriogonum Parryi* n. sp. Gray, Proc. Am. Acad., vol. x, p. 77. Rocky slopes near St. George, May; very variable in size, in robust specimens the leaves fully two inches broad.

No. 240. *Eriogonum trichopodum* Torr. & Gray. l. c., p. 185. One of the common gregarious species, which in the season of flowering in the latter part of May, gives a peculiar yellowish green color to the hills adjoining St. George.

No. 241. *Eriogonum ovalifolium* Nutt. Torr. & Gray, l. c., p. 164. Beaver-dam mountains. May.

No. 242, 244. *Eriogonum microthecum* Nutt. Torr. & Gray, l. c., p. 170. Cedar City. July.

No. 243. *Eriogonum villiflorum* Gray. Proc. Am. Acad., vol. viii. p. 630. Cedar City. July.

No. 245. *Eriogonum spathulatum* n. sp. Gray, Proc. Am. Acad., vol. x, p. 76. Lower valley of the Sevier. July.

No. 246. *Rumex hymenosepalus* Torrey. Bot. Mex. Bound., p. 177. Abundant on dry sandy or rocky slopes near St. George; the young tender shoots in domestic use as a substitute for rhubarb. May.

——. *Shepherdia rotundifolia* n. sp. Silvery tomentose and scurfy; leaves persistent, round-oval or ovate, mostly somewhat cordate, shortly petioled, beneath densely stellate-white scurfy, as well as the branches, above less scurfy and greenish; flowers all in the axils of ordinary leaves, on pedicels about the length of the perianth, the male flowers mostly in threes and the female solitary; filaments very short, glabrous; fruit globular, scurfy; akene ovate, unequally channelled at base.—On bare clay soil in the upper valley of the Virgen, A. L. Siler, 1873. Forming low densely branched bushes with dull-colored evergreen foliage; flowering in March, perfecting its fruit in July.

No. 247. *Euphorbia Parryi* n. sp. Annual, erect, slender, pale-green, glabrous, with dichotomous spreading branches; leaves linear, nearly equal at base, acutish or acute at both ends, with setaceously slit stipules; involucres campanulate, on moderately long peduncles in the forks of the branches, with unequal small truncate appendages; styles short, somewhat erect; capsule sharp-angled; seeds ovate, minutely granulate. —— St. George, in loose drifting sand. Plant about a span in height; leaves ½-1 inch long, ½ line wide, rolled inward when drying; involucres ⅔-1 line long, and with the greenish-white appendages of the same width; stamens numerous, with conspicuous feathery bracts between them; styles about the length of the ovary; seeds ⅔ line long, rather thick, obtusely angled, surface covered with minute granules, disposed in transverse lines. Habit very similar to *E. revoluta* Engel., but this has a dark purplish-green color, revolute not involute leaves, very much smaller, slender turbinate involucres on short peduncles, and smaller, sharp-angled, strongly cross-ribbed seeds. The charac-

ters of our species point to an alliance with *E. zygophylloides* Boiss. — Dr. G. ENGELMANN.

No. 248. *Celtis occidentalis* L., var.

No. 249, 251. *Ephedra antisyphilitica* C. A. Meyer. Watson, King's Rep., p. 238, t. 39.

No. 250. *Ephedra trifurca* Torr. Watson, l. c., p. 239. Not uncommon on bare saline wastes in the valley of the Virgen. May.

No. 252. *Allium Palmeri* Watson. King's Rep., p. 487, t. 37, fig. 10–11. High mountains east of Cedar City. July.

No. 253. *Androstephium breviflorum* Watson. Am. Naturalist, vol. vii, p. 303. Common on rocky hills near St. George. April.

No. 254. *Calochortus flexuosus* Watson, l. c., p. 303. A fine large-flowered species, which on account of its branching habit continues to put forth its showy tulip-like flowers for several weeks. May.

No. 255. *Calochortus Nuttallii* Torr. & Gray. High mountains east of Cedar City. July.

No. 256. *Milla capitata* Baker, var. *pauciflora* Torr. Watson, King's Rep., p. 490.

No. 257. *Yucca brevifolia* Engel. King's Rep., p. 496. Beaver-dam mountains; flowering in May. See above, Am. Naturalist, vol. ix. p. 141.

No. 258. *Anemopsis Californica* H. & A. Bot. Beechey, p. 390, t. 92.

No. 259. *Polypogon Monspeliensis* Desf. Frequent on the borders of ditches, St. George. June.

No. 260. *Tricuspis pulchella* orr. Bot. Whip. Rep., p. 156.

No. 261. *Aristida purpurea* Nutt. Steud. Gram. p. 134.

No. 262. *Adiantum Capillus-Veneris* L. Moist rocks about springs near St. George.

——. *Notholæna tenera* Gillies. Crevices of perpendicular limestone rocks in a deep ravine near the base of Beaver-dam mountains, twelve miles southwest of St. George, May. Hitherto found only in Chili and Bolivia. The present specimens are smaller and more delicate than those from S. America, but not otherwise different. From *N. Fendleri* and *N. dealbata* it may be distinguished by the oblong outline of the frond and the entire absence of white powder beneath. — Prof. D. C. EATON.

No. 263. *Notholæna Parryi* n. sp. Caudex short, inclined, laden with rather rigid lance-acuminate fulvous scales having a blackish mid-rib; stipes 1½–3 inches long-tufted, dark brown, minutely striated, pubescent with white articulated often gland-bearing hairs; fronds as long as the stipes, oblong-lanceolate, about tripinnate, lower pinnæ distant; segments crowded, roundish obovate, about one line long, densely covered above with entangled white hairs like those of the stipe, and beneath with a similar pale-brown tomentum; sporangia blackish, when ripe projecting beyond the margins of the segments. — Crevices of basaltic rocks near St. George. April. — Prof. D. C. EATON.

——. *Æcidium biforme* n. sp. Peridia clustered, some short with a wide entire mouth, others elongated with the mouth more or less lacerated, the wall-cells mostly pentagonal or hexagonal; spores sub-globose, golden yellow, .0007 to .0008 inch in diameter. — Parasitic on both sides of a leaf of *Heliotropium Curassavicum* L., St. George, May. The peculiar feature of this species is in the peridia, which are either long or short, and equally abundant on both sides of the leaf, projecting each way from the same subiculum. — C. H. PECK.

ERRATA.

Page 16, 13th line from bottom, for *Phacelia crassifolia* Torr. read *Phacelia pulchella* n. sp.

Page 16, 7th line from bottom, for *Phacelia curvipes* n. sp. (?) read *Phacelia cephalotis* n. sp.

Page 16, 6th line from bottom, for *P. Palmeri* Torr. read *P. integrifolia* Torr.

Page 18, 10th line from top, for *Culochortus* read *Calochortus*.

Page 18, 18th line from top, for *Capillus-venesis* L. read *Capillus-Veneris* L.

Page 20, 15th line from bottom, for *polygalrides* read *polygaloides*.

Page 201, 11th line from bottom, for *Trifolium Bolanderi* read *Trifolium Kingii*.

BIOGRAPHIES OF SOME WORMS.

BY A. S. PACKARD, JR.

RETURNING from our journey through the subkingdom of the Mollusca, we will follow the path leading from the Worms up to the Insects. The lowest worms are far more simple in structure than the lowest mollusks. Indeed in organisms like the Vortex, for example, we have forms which serve as a point of departure, ancestral forms, from which the entire animal world above the Infusoria may have been originally derived.

The division of worms is now so vast and unwieldy that it seems impossible to give a general definition of it, and in the present state of science it may be unnecessary. The group embraces all grades of development from simple ciliated forms like the Vortex, Prostomum and Macrostomum, which are scarcely more complicated than the ciliated infusoria, differing chiefly in having genuine cells composing the tissues, up to animals like the earth worms and nereids which are in some respects as high if not higher than the Crustacea and insects.

Claparède in his "Beobachtungen," etc., says that "the Rhabdocœla have interested me on account of their undeniable passage to the ciliated Infusoria. I am truly of Agassiz's opinion that many so-called Infusoria may be simply Turbellarian larvæ; although at first opposed to this opinion I afterwards expressed my views as to the near relationship of the Infusoria as well with the Rhabdocœla as the Dendrocœla. Thus as *Trachelius ovum* forms an evident connecting link between the Infusoria and Dendrocœla, so are the early stages of the Rhabdocœla often scarcely to be distinguished from the Infusoria. In many cases one is in doubt whether he is dealing with a young Turbellarian worm or a ciliate Infusorian." He then describes an Infusorian-like worm in which the mouth opens by a pharynx into a broad body and digestive cavity, with no anal opening. There is thus no digestive cavity separated from the body cavity. There are no other organs except an otolite. This is evidently an immature form, but none the less closely allied structurally to Paramecium and Trachelius.

It should also be remembered that among the worms are many synthetic types which, as regards some organs, remind us of other groups of animals. For example the Rotifers recall the lower Crustacea, and are by some naturalists regarded as such; the Planarians have been considered by Girard, as mollusks, the Polyzoa and Brachiopods are still regarded as mollusks by eminent naturalists, and there are very few who do not place the Tunicates among the latter. On the other hand the Echinoderms are regarded as worms by some, and Amphioxus has been called a worm. Indeed if any one has any prejudices regarding fixed types in nature, and would learn how regardless of preconceived zoological systems the actual state of our knowledge of the lower animals must lead one to become, let him study the animals now placed among the "Worms."

Leaving out of consideration the lowest forms, almost without organs, and many parasitic forms, as a general rule the worms are bilateral, segmented animals with the nervous cords either separate or united by commissures, and resting on the floor of the body under the alimentary canal, which usually (when present) passes directly through the middle of the body. There is in the Annelides a dorsal and ventral blood-vessel, the circulatory apparatus being closed and more highly developed than in the Crustacea and Insects, Limulus excepted. In the lower worms (Platyelminths, Nematelminths, Acanthocephali and Rotatoria) there is a complicated system of excretory tubes, thought by some anatomists to be analogous with the water-vascular system of Radiates.

The organs of locomotion are, when present, simple bristles or prolongations of the walls of the body forming paddle-like flaps.

We are now concerned with tracing the mode of development of some of the typical forms belonging to the different subdivisions, the general relations of which may be seen in the following tabular view, which is taken from Gegenbaur's "Principles of Comparative Anatomy," with the addition of the Brachiopoda, which he still retains among the Mollusca. The Onychophora, represented by Peripatus, are also omitted, as since the publication of Gegenbaur's work, Peripatus has been proved by the researches of Mr. Moseley to be a tracheate Insect.

VERMES.

I. PLATYELMINTHES.
  Turbellaria (Vortex, Prostomum, Planaria).
  Trematoda (Distoma, Monostomum).
  Cestoda (Tænia, Bothriocephalus).
  Nemertina (Nemertes).
II. NEMATELMINTHES.
  Nematodes (Strongylus, Ascaris).
  Gordiacea (Gordius, Mermis).
III. CHÆTOGNATHI (Sagitta).
IV. ACANTHOCEPHALI (Echinorhynchus).
V. ROTATORIA (Brachionus, Rotifer).
VI. POLYZOA (Alcyonella, Flustra, Lepralia).
VII. ENTEROPNEUSTI (Balanoglossus).
VIII. TUNICATA (Appendicularia, Ascidia, Pyrosoma, Doliolum, Salpa).
IX. GEPHYREA (Sipunculus).
X. BRACHIOPODA (Lingula, Terebratulina).
XI. ANNULATA (Hirudo, Lumbricus, Nereis, Serpula).

I. PLATYELMINTHES (Flat Worms, Flukes and Tape Worms).

These are flat-bodied ciliated worms without lateral appendages, usually with hooks or suckers. They are usually hermaphroditic.

Development of the Turbellaria. These lowest of worms, in which there is no true stomach and intestines, but a simple short blind digestive sac leading from the mouth and pharynx, are known to multiply by fission, the body dividing into two. They also possess ovaries and male glands, and reproduce from eggs. We are not acquainted with the life-history of the Rhabdocœlous forms, such as Vortex, Prostomum, etc., except that we know that they produce eggs and spermatic particles. In Prostomum, an orbicular form, the yolk cells are formed in a gland (vitellogene) distinct from the true ovary or germ-forming gland (germogene). As an example of reproduction by fission may be cited the singular *Catena quaterna* Schmarda, which occurs in fresh water at the Cape of Good Hope. Fig. 161 represents two individuals in partial division, and a chain of four individuals, natural size. This form reminds us of the tape worm, in

Fig. 161.

Catena quaterna.

which the joints remain permanently attached. We know nothing further regarding the history of Catena except that it has been found as indicated in the figure here reproduced from Schmarda.

Among the Dendrocœla, or Planarians, and in fact in the flat worms generally, fission takes place. If we cut the common fresh water Planarians into several pieces, each piece will become a perfect worm.

All the fresh water flat worms are born as infusorian-like ciliated bodies which attain maturity without any metamorphosis. As an example of the mode of development of a Planarian worm, may be given the history of *Planocera elliptica* discovered by Girard in Boston and Beverly harbors. The spawning time lasts from the middle of May until the middle of June, the eggs being deposited in a thin viscid band on stones and sea weeds. The egg undergoes total segmentation in four or five days after. A ciliated blastoderm begins to form around the yolk mass, and before the embryo leaves the egg it assumes the larval shape, being an infusorian-like form, with a caudal flagellum. There are no internal organs except two eye-specks.

In eight or ten days after the larva begins to revolve in the egg, and after it has hatched, it stops swimming about and becomes a "mummy-like body" which Girard calls a "chrysalis." In this condition, which apparently corresponds to the encysted state of the flukes, it floats about in the water. Here Girard's observations came to an end. Whether in this resting stage it is swallowed by some other animal, and becomes a parasite before resuming its active life, remains to be seen.

The later history of *Planaria angulata* has been traced by Mr. A. Agassiz. "On examining," he says, "a string of eggs, mistaken at first for those of some naked mollusk, I was surprised to find young Planariæ in different stages of growth with a ramifying digestive cavity, somewhat similar to that of adult specimens, but showing besides, one distinct articulation for each spur of the digestive cavity. The eyes were well developed, and when the young became free, the articulations were still distinct." In the youngest specimen (Fig. 162) observed, the body was almost cylindrical, while as seen in Fig. 163, the body has become considerably flattened. The fact that before attaining maturity the Planarian is articulated is very significant, showing that these low worms, non-segmented in maturity, should not be excluded

from the class of worms, and that the terms "bilateral, articulate" applies as well to the lowest division (though with many exceptions) of worms as to the true Annelides.

Fig. 162.

Fig. 163.

Young Planaria.

The Turbellaria then, so far as our limited knowledge extends, develop (*a*) by fission, (*b*) from eggs fertilized by sperm cells, and pass through the following stages, not, however, all observed in a single species.

1. Morula.
2. Infusorian-like stage.
3. A quiet, encysted (?) stage (Girard's Planocera).
4. Articulated stage observed in one species (Agassiz's *Planaria angulata*).
5. Adult, ciliated, not segmented.

Development of the Trematodes. The flukes are parasitic worms, with a sucking disk in the centre of the body by which they attach themselves on or within the body of their host. The fluke or "liver worm" (*Distoma hepaticum*) lives in the liver of the sheep and of man. The fishes and snails are much infested by them, nearly each species having its distinct kind of fluke. The adult flukes are not ciliated, the alimentary canal ends in a blind sac, and the sexes are united in the same individual.

For the mode of formation of the egg of the Trematodes, and the embryonic history of certain forms, the student is referred to Leuckart's "Menschlichen Parasiten" and E. Van Beneden's beautiful "Researches." E. Van Beneden has shown that the development of the Trematodes begins by subdivision of the germinative cellule or nucleus. The nucleus and nucleolus then divide and subsequently the "protoplasmic body." The yolk, however, remains entirely independent of this division, and serves as nourishment for the other cells forming the body of the embryo.

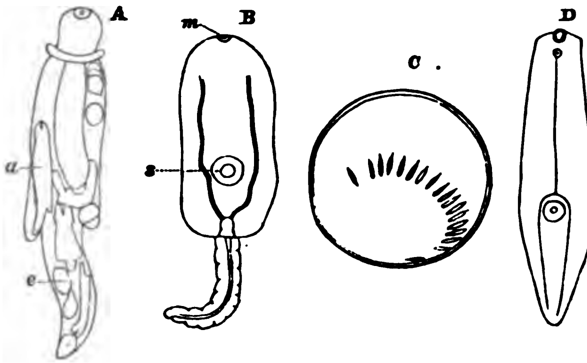
From Van Beneden's observations, it appears that the eggs of the lower flukes as a rule undergo total segmentation, and the young are hatched either oval, ciliated, Infusorian-like, without any organs, not even eye-specks, as in Distoma and Amphistoma; or as in the higher Trematodes, as shown by the elder Van

Beneden, the development is direct, the embryo passing directly into a form like the adult.

For the further history of the fluke we will turn to Steenstrup's famous work "On the Alternation of Generations," wherein is first related the strange history of these animals. While the flukes were well known, as well as the tadpole-like Cercaria, it was not known before the publication of Steenstrup's work in 1842, that the Cercariæ were the free larval forms of the Distomæ. The *Cercaria echinata*, first described by Siebold, is like a Distoma except that the body is prolonged into a long extensible tail. This tail, says Steenstrup, is formed of several membranes or tubes placed one within the other, of which the outermost is a very transparent epidermis, under which is a tolerably thick membrane furnished with transverse muscular fibres or *striæ*, and between each pair of these transverse fibres is placed a globular vesicle which appears to be a mucous follicle or gland; the innermost tube is opaque and of firmer consistence, it contains the longitudinal muscular fibres, and is usually reticulated on the surface. Through the centre of these tubes there passes a slightly narrower canal, which becomes very small towards the extremity of the tail. The existence of the same layers in the body itself of the Cercaria, can easily be demonstrated; but the transversely striated layer is here not so much developed. This description of the Cercaria will remind one of the tadpole-like larva of the Ascidians. The apparent homology in structure of the tail of the Cercaria with that of the Ascidian larva as figured by Kupffer, is striking. This similarity may be seen if the reader will compare fig. 7, Tab. ii, in De la Valette St. George's "Symbolæ," representing a stage in the development of *Cercaria flava* into *Monostomum flavum*. The author figures a row of cells on each side of a central cavity through which passes what is regarded as possibly a nerve. Whether this is not as much a *chorda dorsalis* and spinal nerve as those parts regarded as such in the Ascidian larva, is a subject for future investigation. But in other respects the position of the mouth, the sense-organs, as well as the form of the body strikingly recall the Ascidian larva, so much so that it gives strong confirmation to the opinion that the Ascidians are worms, and that they and the Trematodes have possibly originated from allied forms. In another species, *Cercaria ocellata*, the tail has a lateral fin; and in still another species figured by J. Müller

on the same plate (*Cercaria setifera*) unaccompanied by any description, the tail contains an axial row of large cells, with a row on each side reminding one of the embryo of the Ascidian, with its axial row of cells (the germ of the *chorda dorsalis*) and the

Fig. 164.



Development of Distoma.

cells on each side; moreover the tail is provided with nineteen pencils of long hairs, each pair arising from a distinct segment, so that in one larval Trematode at least, the annulated structure of the body exists, as well as in the larval Planaria.

Fig. 165.

Development of Monastomum.

Returning now to Steenstrup's narrative, he tells us that these "Echinate Cercariæ (Fig. 164, A, parent nurse; *e*, germs; *a*, nurse; B, larva), are found by thousands, and frequently by millions in the water, in which two of our largest fresh-water snails, *Panorbis cornea* and *Limnæus stagnalis*, have been kept." After swimming about in the water some time they fix themselves by means of their suckers (B, *s*) to the slimy skin of the snails, in such numbers that the latter look as if covered with bits of wool.

The Cercaria by contracting its body and violent lashing of the tail forces its way into the body of its host, loses its tail, and then resembles a mature Distoma. By turning about in its place and secreting a mucus, a cyst is gradually formed, with a spherical shell. This constitutes the "pupa" state of the Cercaria, first

observed by Nitzsch and afterwards by Siebold. Steenstrup thinks that the Cercaria casts a thin skin. In this state the body can be seen through the shell of the cyst, as in Fig. 164, C, where the circle of spines embedded around the mouth is seen.[1] The encysted Cercariæ remain in this state from July and August until the following spring; and during the winter months in snails kept in warm rooms, they change into Distomas (Fig. 164, D) the mature fluke differing, however, in some important respects from the tailless larvæ. In nature they remain from two to nine months in the encysted state.

"Now," asks Steenstrup, "Whence come the Cercariæ?" Bojanus states that he saw this species swarming out from the "king's yellow worms," which are about two lines long and occur in great numbers in the interior of snails. From these are developed the larval Distomas, and Steenstrup calls them the "nurses" of the Cercariæ and Distomata. They exactly resemble the "parent nurses" (Fig. 164, A) and like them the cavity of the body is filled with young, which develop from egg-like balls of cells. Steenstrup was forced to conclude that these nurses originated from the first nurses (Fig. 164) which he therefore calls "parent-nurses." Here the direct observations of Steenstrup on the *Cercaria echinata* came to an end, but he believed that the parent-nurses came from eggs. The link in the cycle of generations he supplied from the observations of Siebold, who saw a Cercaria-like young (Fig. 165, B) expelled from the body of the ciliated larva of *Monostomum mutabile* (Fig. 165, A, *a*, nurse developing from ciliated larva; *m*, mouth; *b*, eye specks). Steenstrup remarks that "the first form of this embryo is not unlike that of the common ciliated progeny of the Trematoda, as they have been known to us in many species for a long time, from the observations of Mehlis, Nordmann and Siebold, and it might at first sight be taken for one of the polygastric infusoria of Ehrenberg, which also move by cilia; whilst in the next form which it assumes the young Monostomum bears an undeniable resemblance to those animals which I have termed 'nurses' and 'parent nurses' in that species of the Trematoda which is developed from the *Cercaria echinata*."

Thus the cycle is completed and the following summary of

[1] Other figures by Steenstrup and other authors show the form of the encysted Cercaria very distinctly, but in the figure given above only the spines are distinctly represented in the plate from which this is copied.

changes undergone by the lower Distomas present as clear a case of an alternation of generations as seen in the jelly fishes.

1. Egg.
2. Morula.
3. Ciliated larva.
4. Cercaria (parent nurse, Proscolex) producing
5. Cercaria (nurse, scolex).
6. Encysted Cercaria (Proglottis).
7. Distoma (Proglottis).

The *Cercaria echinata*, living in snails which are eaten by ducks, have been shown by St. George to develop into the adult Distoma in the body of that bird. It is generally the case that those Distomas which pass through an alternation of generations live in the larval state in animals which serve as food for higher orders. Thus the Bucephalus of the European oyster passes in the encysted state into a fish (Gasterostomum), which serves as food for a larger fish, *Belone vulgaris*, where the cysts of the same worm occur.

Distoma hepaticum, the liver fluke, sometimes occurring in man, is thought by Dr. Willemoes-Suhm to begin its existence as *Cercaria cystophora*, parasitic on a species of Planorbis.

LITERATURE.

Steenstrup. On the Alternation of Generations. 1842. Translated by G. Busk, 1845.

De la Valette St. George. Symbolæ ad Trematodum Evolutionis Historiam. Berlin, 1855.

Leuckart. Die Menschlichen Parasiten. Leipzig. 1868, incomplete.

E. Van Beneden. Recherches sur la Composition et la Signification de l'Oeuf. Bruxelles, 1870.

Development of the Cestodes. In the tape worm there is no alimentary canal, the liquid food being absorbed from the juices of its host through the walls of the body. The head is armed with suckers, hooks or leaf-like soft appendages, while the body is subdivided usually into a great number of segments, each containing an ovary and male gland. While the Turbellaria possess a pair of nerve-ganglia, the Cestodes are not known positively to possess any trace of a nervous system.

E. Van Beneden shows that the egg is formed by two glands, one of which (the germogene) forms the nucleus and nucleolus, while the other (vitellogene) forms the yolk. Development begins very probably as in the Trematodes, by multiplication by division of the nucleus (germinative cell). In the eggs of *Tænia bacil-*

laris E. Van Beneden saw the nucleus subdivide; afterwards the cells are arranged in two layers, and the outer layer is thrown off (this probably corresponding to the amnion of insects and crustacea); the central mass forms the embryo, and soon the three pairs of hooks arise as in Fig. 166. Three structureless membranes are secreted around the embryo, which then hatches. The embryo of Bothriocephalus is provided with a ciliated membrane, which corresponds to the first blastodermic moult of the embryo Tænia, which is not ciliated.

Fig. 166.

Embryo of Tænia.

Fig. 167.

Common Human Tape worm.

Now taking up the history of the human tape worm, *Tænia solium* (Fig. 167[1]), the eggs eaten by the hog are developed in its body into the larval tape worm (scolex) called in this species, *Cysticercus cellulosæ*, (Fig. 168; Fig. 169, head enlarged). The head with its suckers is formed, the body becomes flask-shaped (Fig. 168, Cysticercus); the Cysticerci then bury themselves in the liver or the flesh of pork, and are transferred living in uncooked pork to the alimentary canal of man. The body now elongates,

[1] *Tænia solium.* A, the worm natural size: *h*, head; *a*, 309th joint; *b*, 448th; *c*, 569th; *d*, 680th; *e*, 768th; *f*, 849th; *g*, 855th joint and last but one. This worm was 10 feet 9 inches long. B, a separate joint (Proglottis) showing the ovary with its outlet *o*; the same joint contains a testis, too minute to show in the figure. Fig. 168, *Cysticercus cellulosæ*. the larval tape worm, *a*, circle of hooks; *b*, suckers; *c*, wrinkled neck; *d*, sac filled with fluid. This and Fig. 166 and 169 from Weinland.

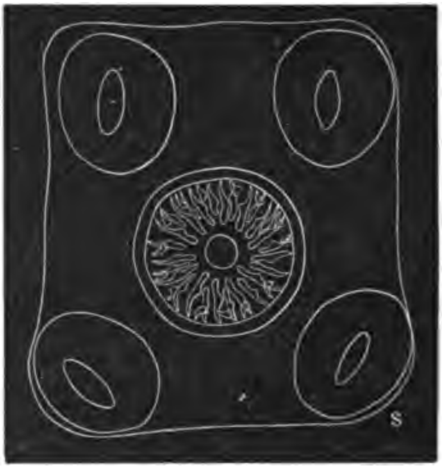
new joints arise behind the head until the form of the tape worm is attained, as in Fig. 167, after Weinland.

Now we shall see how the eggs are produced. The hinder joints become filled with eggs and then break off, becoming independent animals comparable with the "parent-nurses" of the Cercarias, except that they are not contained in the body of the Tænia (as in the Cercaria), but are set free. The independent joint (Fig. 167, *g*, is called a "proglottis." It escapes from the alimentary tract, and the eggs set free are swallowed by that un-

Fig. 168.

Cysticercus, or larval Tape worm.

Fig. 169.



Head of Cysticercus enlarged, showing the suckers (S) and circle of hooks.

clean animal, the pig, and the cycle of generations begins anew. We thus have the following series of changes which may be compared with the homologous series in the flukes:

1. Egg.
2. Morula.
3. Double-walled sac (Planula?).
4. Proscolex, free embryo with hooks, surrounded by a blastodermic skin (Amnion?).
5. Scolex (Cysticercus, larva). Body few-jointed.
6. Scolex (Tænia). Body many-jointed.
7. Proglottis (adult).

LITERATURE.

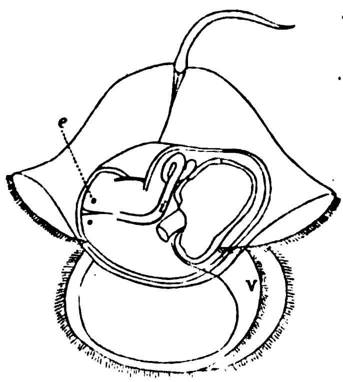
P. J. Van Beneden. Les Vers Cestoïdes. Brussels. 1850.
— ———. Memoire sur les Vers Intestinaux. Paris. 1858.

Siebold. Ueber die Band- und Blasenwürmer. Leipzig. 1854.
Weinland. An Essay on the Tapeworms of Man. 1858.
Compare also the works of Leuckart, Küchenmeister, E. Van Beneden and Cobbold.

Development of the Nemerteans. In the development of some of these worms we are reminded of the mode of growth of the Echinoderms, while in others the larvæ attain the adult condition by gradual development. In no order of animals, perhaps, is there a greater range of variation in the mode of development than in these curious worms.

The simplest mode of growth is that described by Dieck in Cephalothrix, where the ciliated larva, after passing through a morula and plannla[1] stage (being a two-layered sac, but not a gastrula) leaves the egg and undergoes no metamorphosis, the young worm having no body cavity. In the Nemertes larva of Desor there is a body cavity, but the larva is still an infusorian-like being, and attains maturity by direct growth. Another Nemertean (*N. communis*) has been found by Barrois to have a somewhat more complicated mode of growth than in the larva of Desor. The first stages of development are like those of the larva of Desor, the morula passing, as he claims, into a ciliated "gastrula" state in the egg, the body cavity being formed by invagination of the outer layer of cells, but the animal after shedding an amnion leaves the egg in the Nemertes form, and there is no free swimming stage.

Fig. 170.



Pilidium with the Nemertes growing in it.

Now we come to those Nemerteans in which there is a very complicated metamorphosis. J. Müller had described an animal caught with the towing net which he called "Pilidium." Busch had suspected that a Nemertes came from the Pilidium, and Leuc-

[1] The inner lining of the planula arises before the body cavity is formed, by a differentiation of a second inner cell-layer, as occurs in other worms, zoophytes, etc. Dieck evidently limits the term gastrula to a two-layered sac, with a body cavity formed by the invagination of the ectoderm Lankester's "gastrula" includes any embryo with a two-layered sac and a primitive cavity. Dieck's planula is like Hæckel's planula of the sponge, the cavity being formed during the segmentation of the egg.

kart and Pagenstecker proved it. Our figure taken from the drawings of these two last named authors shows the singular Pilidium, and the planarian-like Nemertes with the eye-specks (Fig. 170, *e*), growing in it. How the worm originates in the body of the Pilidium, and how the latter arises, have lately been fully shown by Metschnikoff, and to his memoir we are indebted for the strange history of the alternation of generations in these worms.

He followed the development of the Pilidium from the egg, which undergoes total segmentation, leaving a segmentation-cavity. The next occurrence is the separation of a one-layered ciliated blastoderm, the ectoderm, which invaginates, forming the primitive digestive cavity, from which the stomach and œsophagus are formed. The larva is now helmet-shaped, ciliated, with a long lash (flagellum) attached to the posterior end of the body.

After swimming about on the surface of the sea awhile, the Nemertes begins to grow out from near the œsophagus of the Pilidium. On each side of the base of the velum (*v*) of the Pilidium appear two thickenings of the skin, one pair in front, the other behind; these thickenings push inwards, and are the germs of the anterior and posterior end of the future worm. The anterior pair become larger than the posterior; the part of the disk next to the œsophagus thickens; at the same time the alimentary canal of the Pilidium grows smaller and only a narrow slit remains. The disks now divide into two layers, the outer much thicker than the inner. A new structure now arises, a pair of vesicles near the hinder pair of disks; these are the "lateral organs" of the future worm. Soon the anterior pair of disks unite and the head of the worm is soon formed, when the elliptical outline of the flat worm is indicated, and appears somewhat as in Fig. 170 (*i*, intestine of the worm). The yolk mass, with the alimentary canal of the Pilidium, is taken bodily into the interior of the Nemertes, the Pilidium skin falls off, and the worm seeks the bottom.

Metschnikoff discovered five other species of Pilidium, and thinks this mode of development is not an uncommon occurrence. This manner of development is directly comparable with that of the echinoderm from the Pluteus.

To show the wide range of metamorphosis existing in the Nemerteans, we may cite the case of a Nareda studied by Mr. A. Agassiz, and whose early stages are like those of the higher Annelides, in fact so much so that Milne-Edwards and Claparède

Fig. 171.

Fig. 172.

Fig. 173.

Fig. 174.

Fig. 175.

Fig. 176.

Development of a Nemertean worm. After A. Agassiz.

associated "the larva of Lovén" (which Mr. Agassiz has traced without any doubt to the Nemertean worm) with that of Polynoë, a representative of the highest family of Chætopod worms. In the first stage (Fig. 171, *a*, anus; *c*, intestine; *m*, mouth; *o*, œsophagus; *s*, stomach; *e*, eye-speck; *v*, ciliated ring) the larva is not ringed; this figure may be compared with figure 96 on p. 231 to show how much alike the worm and Echinoderm larvæ appear. The new rings are formed between the anal rings and the older anterior rings, as in annelid larvæ, and in fact in the embryos of the Insects and Crustacea. Figs. 172 and 173 represent the ringed larva. "A number of rings make their appearance at once, and are the more distinct the nearer they are placed to the mouth." The worm now greatly elongates, more segments are added and it appears as in Figs. 174 and 175, with the ciliated crown, the small short tentacles and eyes. The worm now swims about slowly and creeps over the bottom, and is nearly a quarter of an inch long. It will be observed that the larva differs from those of other Annelides, as Mr. Agassiz states, in the absence of "feet, bristles or appendages of any sort, except the two tentacles of the head; and, were it not for these, it would seem as if the young worm were the larva of some Nemertes-like animal." Fig. 176 represents the worm over four months after the stage represented by Fig. 175, the articulations have disappeared and a month later the head is separated from the body by a neck, the tentacles disappear, the body is flattened, and the Nemertes (Polia) form is attained.

It is thus interesting to know that the young Echinoderm (Fig. 96), the young mollusk (Fig. 140 B) and the young Nemertean worm pass through a similar free swimming Cephalula stage. We shall see farther on that the young Balanoglossus and the true Annelides pass through a similar phase. The changes through which the Nemertean worms pass are the following, though it should be borne in mind that different species pass through different cycles of growth, some exhibiting no metamorphosis, the stages being more or less condensed in the embryo state.

1. Egg.
2. Morula.
3. Planula (or Gastrula?) hatching as a
4. Ciliated Infusorian-like larva, or a
5. Pilidium or a Cephalula.

6. Nemertes (a) budding out from the Pilidium, or (b) arising by direct growth from the Cephalula.

LITERATURE.

Lovén. Jakttagelse ofver Metamorfos hos en Annelid. (K. Vet. Akad. Handlingar. Stockholm, 1840. Translated in Archiv fur Naturgeschichte. 1842, and Annalcs des Sc. Nat. 1842.)

Desor. Embryologie von Nemertes. (Muller's Archiv, 1848.)

Leuckart and Pagenstecker. Untersuchungen ueber niedere Seethiere. (Muller's Archiv, 1858.)

A. Agassiz. On the young stages of a few Annelides. (Annals Lyceum of Natural History. New York, 1866.)

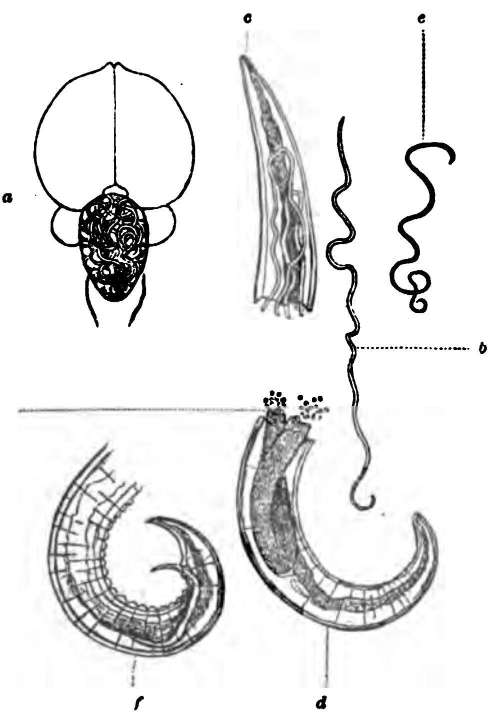
Metschnikoff. Entwickelung der Echinodermen und Nemertinen. (Mémoires Acad. Imp. Sciences. St. Petersbourg, 1869.)

Dieck. Beiträge zur Entwickelungsgeschichte der Nemertinen. (Jenaische Zeitschrift für Naturwissenschaft. 1874.)

II. NEMATELMINTHES (Round worms, Thread worms, Hair worms.)

There is little of interest in the development of the ordinary round worms, which whether free or parasitic are of the usual form, as shown in the Eustrongylus.

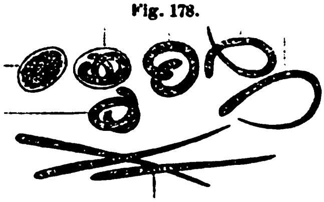
Fig. 177.



The mode of development of all these worms so far as known is very uniform. Development begins in three ways: (1) usually the egg undergoes total segmentation; others (2), as in *Ascaris dentata* and *Oxyuris ambigua*, do not show any trace of segmentation, and (3) in *Cucullanus elegans* there is no yolk, the nucleus absorbing all the vitelline matter which is limpid and transparent (E. Van Beneden). The germ consists of a single row of cells bent on itself somewhat as in Fig. 178, which represents a little more ad-

vanced state in Sagitta, and there are a few cells representing the entoderm. The Nematode may be said therefore to pass through an incomplete gastrula condition. The adult form is rapidly assumed in the egg. Fig. 178 after J. Wyman, represents the young of *Eustrongylus papillosus* in the egg and the worm just after hatching. Fig. 177, *a*, several mature worms coiled up in the brain of the snake bird; *b*, female; *c*, head much enlarged; *d*, end of the body; *e*, male; *f*, the end of its body, after Wyman.)

Fig. 178.



Development of a Round worm.

The *Trichina spiralis* is the author of the terrible disease called trichiniasis or trichinosis. The young worms exist in the flesh of the hog, where they become encysted, and if swallowed by man, the cysts are dissolved during digestion, and the young worms are set free in the intestinal canal. From here the young bore in all directions in the body, and becoming encysted cause the flesh to look as if sprinkled with white sand.

The development of the hair-worm (Gordius and Mermis) is quite complicated, as the young are parasitic, tadpole-shaped, living in the bodies of insects, especially grasshoppers, in whose bodies the mature worms are found coiled up. M. Villot is now publishing an account of the mode of development of these worms in a monograph appearing in Lacaze-Duthiers "Archives, but not yet completed. These worms are oviparous, laying exceedingly numerous, minute eggs agglutinated together, forming long white strings. The young of one genus live in the aquatic larvæ of flies and were afterwards found by Villot in the mucous layer of the intestines of fishes.

The diœcious round worms pass without metamorphosis through a morula, and a condensed gastrula state (not so well marked as in Sagitta) in the egg, assuming the adult form before hatching. In the hair worms there is a well marked metamorphosis.

LITERATURE.

Claparède. De la Formation et de la fécondation des Œufs chez les Vers Nématodes. Genève, 1859. Compare also papers by Bagge, Reichert, Siebold, Nelson, Schneider, Perez, E. Van Beneden and Villot.

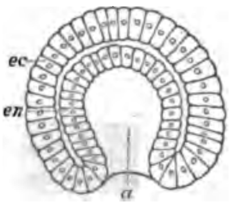
III. CHÆTOGNATHI (Sagitta).

This singular worm had been referred to the crustacea by some,

to the mollusca by Forbes, and even to the vertebrates by Meissner. Its development and structure, however, show that it is nearly related to the Nematodes. The mouth is, however, armed with six pairs of bristles; and a double-fin-like expansion of the sides and ends of the body gives it a slightly fish-like shape. This fin-like expansion is seen in the Cercaria, and the young ascidian, and is of little morphological importance. It swims on the surface of the water, not seeking the bottom or living parasitically.

Development of Sagitta. This animal is a hermaphrodite, and the eggs may be found in August well developed. Its development has been studied by Gegenbaur and Kowalevsky, by the latter in great detail. The egg undergoes total segmentation, a segmentation cavity being formed and the blastoderm invaginating exactly as in the Nematodes. This results in the formation of a gastrula-condition (Fig. 179) in which the infolding of the blastoderm leaves a well marked primitive body cavity. Soon at the opposite end of the body another cavity (the permanent mouth) forms, which deepens and connects with the primitive body cavity; this closes up at the posterior end, and the true digestive canal is formed. The embryo is oval, but soon elongates, and the adult Sagitta form is attained before the animal leaves the egg.

Fig. 179.



Gastrula of Sagitta.

The phases of development are then as follows:

1. Morula.
2. Gastrula (well marked, but not ciliated and free).
3. Adult Sagitta.

LITERATURE.

Gegenbaur. Ueber die Entwickelung der Sagitta. Halle, 1857.
Kowalevsky. Embryologische Studien an Würmen und Arthropoden. (Memoirs Acad. Imp. Sciences. St. Petersburg, 1871.)

IV. ACANTHOCEPHALI.

The Echinorhynchus (Fig. 180, head, after Owen); 181, the same, with the proboscis retracted (*a*, oral pore; *bb*, protractile muscles; *cc*, retractile muscles; from Owen), a singular worm,

without a mouth or alimentary canal, but with a large proboscis armed with hooks, evidently lives by imbibition of the fluids of its host. It is a not uncommon parasite of fishes. Fig. 182 represents an allied(?) form (*Koleops anguilla*) described by Dr. Lockwood, who found it in the eel (AMERICAN NATURALIST, vi, 1872).

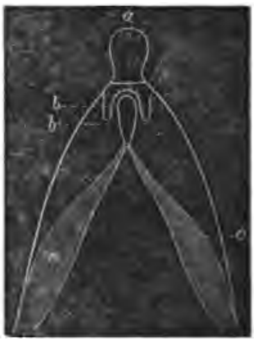
Fig. 182.

Koleops.

Development of Echinorhynchus gigas. Schneider has given the only account we have of the early stages of this worm. "The ova of this worm are scattered upon the ground by the pigs. Here they are eaten by the larvæ of *Melolontha vulgaris* [a beetle allied to our June beetle], and thus arrive at their further development. The ova burst in the stomach of the larva, and the embryos contained

Fig. 180.

Fig. 181.



Head of Echinorhynchus.

in them can then penetrate, by means of their spines, through the intestine into the body cavity of the larva; here they become developed, and again reach the intestine of the pig by the agency of the larva.

"The larvæ infested with Echinorhynchi live on until their metamorphosis into cockchafers. . . . . When the embryos have arrived at the body cavity of the larvæ of Melolontha, they remain for some days unaltered and capable of motion; they then become rigid, acquire an oval form, and envelope themselves in a finely cellular cyst, which is formed of the connective tissue of the larva. The skin of the embryo, with its circlet of spines at the anterior extremity, continues at first to be the skin of the growing larva; and it is only at a later period, when the forma-

tion of the hooks commences, that it is thrown off, when it forms a second cystic envelope. The embryo, or rather the larva, proceeding from it, divides very soon into two layers, a thick dermal layer and an inner cell-mass, from which the other organs originate." The ovaries and testes are produced at a very early stage.

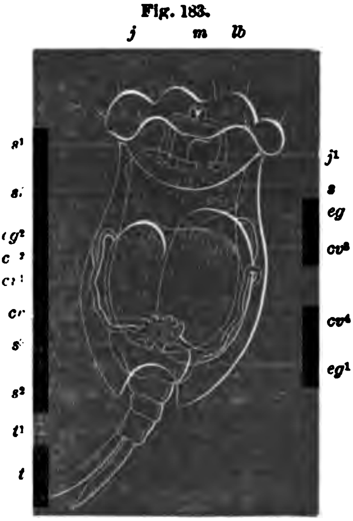
LITERATURE.

Schneider. On the development of *Echinorhynchus gigas*. (Sitzungsbericht der Oberhessischen Gesellschaft für Natur und Heilkunde, 1871. Translated in Annals and Mag. Nat. Hist., 1871.)

V. ROTATORIA.

The Rotifers, by some eminent naturalists regarded as crustacea, are shelled worms, related to the flat-worms in many respects. The body consists of several segments, and the sexes are very unlike, the small males having the organs more or less rudimental, with no alimentary canal. Like the lower worms they have a set of tubes excretory in their nature and perhaps respiratory, corresponding to the water vascular tubes of the Radiates, but with fine ciliated infundibuliform orifices comparable with the segmental organs of the Brachiopods and higher worms; also a pair of teeth in the pharynx; as in many worms. The anus is situated on the back at the base of the tail. Sometimes the digestive canal ends in a blind sac. The distinctive organ is the retractile, ciliated, paired organ which may be called the velum. Fig. 183[1] from H. J. Clark, represents *Squa-*

Fig. 183.



A Rotifer.

[1] *Squamella oblonga*, magnified 200 diameters. From fresh water. A view from below; shell or carapace (s, s^1, s^2); s, the anterior transverse edge of the carapace; s^1, the anterior, and s^2, the posterior corners of the carapace; s^3, the border of the oval, flat area which occupies the lower face of the carapace; *lb*, the cilia bearing velum of the head; *t*, the fork of the tail (t^1); *m*, the mouth; *j*, jaws; j^1, muscles which move *j*; *st*, stomach; *cv*, the contractile vesicle, or heart of the aquiferous circulatory system; cv^1, cv^2, the right, and cv^3, cv^4, the left aquiferous circulatory vessels; *eg*, eg^1, eg^2, two largely developed young.—Clark's "Mind in Nature."

mella oblonga of Ehrenberg, found in this country. It is closely allied to Brachionus.

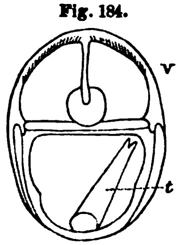
Development of the Rotifers. The sexes are distinct. The females lay both summer and winter eggs, the former being unfertilized, like the summer eggs of the Cladocera (Daphnia). The Rotifers live in damp places in water and revive after being nearly dried up for a long time. Dr. Salensky has been the first to give a complete sketch of the life-history of a Rotifer, *Brachionus urceolaris.*

The eggs of Brachionus are attached by a stalk to the hinder part of the body of the female. The following remarks apply to the female eggs, which are quite distinguishable from the masculine ones. The eggs undergo total segmentation, and the outer layer of cells resulting from subdivision form the blastoderm, when the formation of the organs begins. The first occurrence is an infolding of the blastoderm (ectoderm) forming the primitive mouth, which remains permanently open, the mouth not opening at the opposite end as in Sagitta, but the entire development of the germ is as in Calyptræa, as Salensky often compares the earliest phases of development of the Rotifer with those of that mollusk. The "trochal disk," or velum, as we may call the ciliated disk of the Brachionus, arises as in certain mollusks, as a swelling on each side of the primitive infolding. Behind the primitive hole appears another swelling, which becomes the "foot" or tail.

There is soon formed at the bottom of the primitive infolding a new hole or infolding, which is the true mouth and pharynx, while a swelling just behind the mouth becomes the under lip.

Soon after, the two wings of the velum become well marked, and their relation to the head is as constant as in Calyptræa. The foot becomes conical, larger, and the termination of the intestine and anal opening is formed at the base.

Fig. 184.



Brachionus nearly ready to hatch.

The internal organs are then elaborated; first the nervous system, consisting of but a single pair of ganglia arising from the outer germ-layer (ectoderm). Soon after the sensitive hairs arise on the wings of the velum.

Fig. 184 shows the advanced embryo, with the body divided into segments, the pair of ciliated wings of the velum (v), and the long tail (t). At this time the

shell begins to form, and afterwards covers the whole trunk, but not the head.

The inner organs are developed from the inner germ-layer (endoderm), which divides into three leaves, one forming the middle part of the intestine, and the two others the glands and ovaries. The pharyngeal jaws arise as two small projections on the sides of the primitive cavity.

The male develops in the same mode as the female. The Rotifers, so far as can be judged from one species, seem to develop in a manner quite unlike other worms, and in the earliest phases much as in some Gastropods, the mode of their embryology not throwing much light on the affinities of the group, which is of doubtful position, though with more of the characters of worms than crustacea.

The young pass through a morula state, and the embryo directly attains the mature form in the egg.

LITERATURE.

Salensky. Beitrage zur Entwicklungsgeschichte der *Brachionus urceolaris*. (Siebold and Kölliker's Zeitschrift, 1872). Compare also the papers of Huxley, Leydig, Cohn, Gosse and Nägeli.

REVIEWS AND BOOK NOTICES.

Sullivant's Icones Muscorum, or Figures and Descriptions of most of those Mosses peculiar to North America, which have not yet been figured. — *Supplement* (*Posthumous*). With eighty-one copper plates, imp. 8vo. Prefaced by a Biographical Sketch of the author, by Asa Gray. Mr. Sullivant died on the 30th of April, 1873, leaving the plates of this exquisite volume ready for publication, and the letter-press partially so. The latter has been completed by his friend and associate, Mr. Lesquereux; and the volume has at length been brought out, at the expense of Mr. Sullivant's executors, and in accordance with his wishes. Only a very small edition has been printed. The delicate copper plates were not intended for a large impression; and the number of botanists interested in the serious study of mosses is supposed to be small.

As with the larger first volume, with one hundred and twenty-three plates, issued ten years ago, so with this supplementary one now bequeathed to botanists, the sale of the whole edition, at the price for the present fixed, would be far from covering the actual

pecuniary outlay in the production. The work is a gift to bryological science by one of its most distinguished cultivators, who, fortunately, was blessed with the means which enabled him to bestow it. He accordingly fixed a price much below the cost, so as to bring the work fairly within the reach of students who may desire it. This policy will still be adhered to for a sufficient time to enable those in this country who need the work to obtain it advantageously. For the present the price of the original volume will be $14.00; of the supplement $10.00; of the two together, $24.00. It is supplied by the American Naturalists' Agency, as well as by Charles W. Sever, Cambridge, Mass., by Westermann & Co., New York, and by Trubner & Co., London.—Asa Gray.

BOTANY.

Introduction of Ulex europæus in the Bermudas.—In the winter of 1872–3, I sowed English seed of this shrub in my garden, and a few healthy plants were produced in the course of twelve weeks or so. Leaving for the north for the summer months, I thought it best, to insure their safety, to present them to His Excellency the Governor, Major General Lefroy, whose endeavors to introduce new forms of vegetation into the islands are widely known and appreciated. The plants died during the summer. More seeds were then sown in Government House garden and came up well, and being transplanted into favorable positions, throve beyond expectation, and in February last I had the pleasure of seeing several plants, arranged as a thicket on a northwestern slope, in blossom. Still, I was somewhat skeptical regarding the ultimate result, knowing that this form refuses to grow farther south than the latitude of 42° in the eastern hemisphere, but much to my satisfaction the legumes duly formed, and the seeds became fully ripe at the beginning of this month, so that the plant may now be said to be naturalized in these islands.—J. Matthew Jones, *the Hermitage, Bermudas, May* 12, 1875.

ZOOLOGY.

Mr. Gentry's paper on Fertilization through Insect Agency.—It is to be regretted that this interesting paper fails just where it might be of scientific value. If Mr. Gentry, who, by the context of the article evidently anticipated cross fertilization, had enclosed a few female flowers in gauze bags, and self

fertilized them, the case of *Cucurbita ovifera* would have been complete, and in Wistaria how easy to take pollen from some mature flowers and impregnate the younger ones. It is tantalizing to be put off with "incontrovertible" inferences and suggestions, when the material for actual proof was so near at hand.— T. MEEHAN.

COLORADO POTATO BEETLE DESTROYED BY THE ROSE-BREASTED GROSBEAK.—I noticed last summer that great numbers of the Colorado potato beetle were destroyed by the Rose-breasted grosbeak, *Goniaphea Ludoviciana.*

The farmers hold these birds in great favor, and are very careful to prevent their destruction. They were so abundant in this region last summer as to hold in check the vast army of these ravagers of the potato crop.— W. F. BUNDY, *Jefferson, Wis., Feb.* 25, 1875.

THE UMBELLULA.— A monograph of the genus has just been received from Mr. Lindahl, published in the Swedish Transactions. These polypes are sea pens, with a remarkably long stalk, attaining the length of two or three feet. The species are of great rarity, occurring at great depths off Spitzsbergen, Baffin's Bay, North Greenland, and off Cape Finisterre. A second genus, Crinillum, occurred in Banka Sea.

CIGARS DESTROYED BY INSECTS.—The disciples of Mr. Trask will be glad to know that "the weed" is devoured by three kinds of insects, and thus rendered unfit for the use of man. In a collection found by a friend in a lot of cigars, which they had ruined, Dr. Horn enumerates three beetles: *Catorama simplex*, *Xyloteres?* and *Calandra oryzæ.*

GEOLOGY AND PALEONTOLOGY.

THE SAND DUNES OF THE SAN LUIS VALLEY.—On our homeward march while in the service of the U. S. Geological Survey (Dr. F. V. Hayden's) during the summer of 1874, we passed close to the well-known "sandhills" of the San Luis Valley lying at the base of the Sangre de Christo Range opposite Musca Pass. They consist of a range of angular dunes extending in horse-shoe form for some ten miles, the central points of which will average over seven hundred feet in height, making a very prominent object

against the dark back-ground afforded by the Sierras Sangre de Christo and Belanca. Outside of this range of sandhills along their whole extent stretches a perfect *arena* (literally), into the eastern end of which a river of considerable size rushes down, and is utterly lost in five hundred yards, reappearing again, much diminished, several miles below. This floor of sand and the square sides of the dunes to the very top has been ruffled by the wind into small irregular furrows identically the same as the ripple-marks made by the water on a sandy beach. But while the body of this pure fine sand is hammered as compact as that under the waves, the surface is a little softer, so as to readily receive and preserve in ordinarily still weather such delicate marks as the tracks of spiders and small lizards. I noticed also that portions of this ripple-marked floor which had not been recently disturbed, was of a slightly different color from newly exposed sand. It struck me at the time, that sand might easily be blown over this smooth surface without disturbing it, and should it lie there long enough to become rock, this first surface would form a natural line of separation between the strata, having every appearance of an old ripple-marked beach perhaps containing impressions and delicate fossils, when in fact no water had been near it, and the wind alone was accountable for the whole.—ERNEST INGERSOLL.

MICROSCOPY.

DOUBLE STAINING OF WOOD AND OTHER VEGETABLE SECTIONS.—I have lately discovered that benzole fixes the anilines when they are used in staining vegetable and animal tissues. It not only instantly fixes any aniline color in vegetable tissues, but also renders them as transparent as oil of cloves.

Finding that benzole possessed this property, led me to try double staining upon sections of leaves and sections of wood. The results have proved highly satisfactory. I have found the following processes successful:—A section, say of wood, being prepared for dyeing, is put for five or ten minutes in an alcoholic solution of "Roseine Pure" (Magenta), one-eighth or one-quarter of a grain to the ounce. From this it is removed to a solution of "Nicholson's Soluble Blue Pure," one half-grain to the ounce of alcohol, acidulated with one drop of nitric acid. In this it should

be kept for thirty or ninety *seconds*, rarely longer. It should be frequently removed with the forceps during this period, and held to the light for examination, so that the moment for final removal and putting into benzole be not missed. After a little practice the eye will accurately determine the time for removal.

Before placing the object in benzole it is well to hold it in the forceps for a few seconds, letting the end touch some clean surface, that the dye may drip off, and the object may become partially dry. By doing this, fewer particles of insoluble dye rise to the surface of the benzole, in which the brushing is done to remove foreign matter. The object should then be put into clean benzole. In this it may be examined under the glass. If it is found that it has been kept in the blue too short a time, it should be thoroughly dried, and, after dipping in alcohol, be returned to that dye. If a section of leaf or other soft tissue be under treatment, it should be put in turpentine or oil of *juniper*, as they do not contract so much as benzole.

When hæmatoxylon is used instead of magenta, it is followed by the blue as just described. As neither of these dyes comes out in alcohol or in oil of cloves, the section may be kept in the former for a short time before placing in the latter.

The hæmatoxylon dye I prefer is prepared by triturating in a mortar for about ten minutes two drachms of ground Campeachy wood with one ounce of absolute alcohol, setting it aside for twelve hours, well covered, triturating again and filtering. Ten drops of this are added to forty drops of a solution of alum; twenty grains to the ounce of water. After one hour the mixture is filtered.

Into this the section, previously soaked in alum-water, is placed for two or three hours, or until dyed of a moderately dark shade. When dyed of the depth of shade desired, which is determined by dipping it in alum-water, the section is successively washed for a few minutes each, in alum-water, pure water and fifty per cent. alcohol. Finally it is put in pure alcohol until transferred to the blue.

Carmine and aniline blue produce marked stainings, but they are rather glaring to the eye under the glass. I use an ammoniacal solution of the former, double the strength of Beale's, substituting water for glycerine. In this a section is kept for several hours. On removal it should be dipped in water, and then put for a few

minutes in alcohol acidulated with two per cent. of nitric acid; then in pure alcohol; then in the half-grain blue solution before spoken of, from which it should be removed to alcohol; then to oil of cloves. Much color will be lost in the acid alcohol. The acid is to neutralize the ammonia, which is inimical to aniline blue. Magenta aniline or hæmatoxylon may be used with green instead of blue aniline. The brand of green I prefer is the iodine brand, one grain to the ounce of alcohol.

Double stainings of sections of leaves in which red is first used, have the spiral vessels stained this color, other parts being purple or blue. Radial and tangenital sections of wood have the longitudinal woody fibres red, and other parts purple or blue.

This selection of color is, I think, due to the fact that spiral vessels and woody fibres take up more red than other parts, and are slower in parting with it. The blue, therefore, seems first to overcome the red in parts where there is less of it. It will entirely overcome the red if sufficient time be given.

If the blue be used before the magenta aniline, the selection of color is reversed.

I would here call special attention to the importance of examining these stainings at night, as the red in them has a trace of blue in it which does not show at that time, but comes out so decidedly by daylight, as to change, even spoil, the appearance of the specimen.

I think they should be mounted in Canada balsam, softened with benzole, as the presence of the latter may be beneficial in preserving its magnets.

I would offer a few words upon section-cutting, and upon preparing sections for dyeing.

To cut a thick leaf, place a bit of it between two pieces of potato or turnip, and tie with a string. Cuts may be made along the midrib, or across it, including a portion of leaf on either side, or through several veins. Fine shavings of wood may be used, or pieces rubbed down on hones.

Sections of leaves may be decolored for staining by placing for some time in alcohol; but I would recommend the use of Labarraque's solution of chlorinated soda, for a few hours after the alcohol. Especially do I recommend the Labarraque for all kinds of wood. In twelve hours wood is generally bleached; too long a residence in it will, however, often cause it to fall in pieces.

After removing from the soda, wash through a period of twelve or eighteen hours in half a dozen waters, the third of which may be acidulated with about ten drops of nitric acid to the ounce, which acid must be washed out. Next put in alcohol, in which sections and also leaves may be kept indefinitely, ready for dyeing.

Magenta, when used for leaves, should be of the strength of one-eighth or one-quarter of a grain to the ounce of alcohol, and purples and iodine-green two or three times as strong. These anilines are inferior to the blue in bringing out all the anatomical parts of a leaf, including the beautiful crystals so often met with. On removal from the dye, leaves should be thoroughly brushed with camel-hair pencils.

One week, instead of forty-eight hours, is frequently required to effect the decoloration of large leaves in chlorinated soda, even when they are cut into several pieces, which is advisable.

Mr. L. R. Peet, of this city, whose stainings in aniline are unsurpassed for beauty, thinks better results are attained by commencing with a weak dye, say from one-twentieth to one-twelfth of a grain, and slowly increasing the strength of the dye, at intervals of from one to three hours, until the required hue is obtained. This process certainly guards against too deep staining, and may give a finer tone to leaves under the glass.—Geo. D. Beatty, M.D., *Baltimore, in Science-Gossip.*

NOTES.

American Association for the Advancement of Science.—The 24th meeting of the Association will be held in Detroit, Mich., beginning on *Wednesday, August* 11, next. The circular of the Permanent Secretary states that the headquarters of the Association will be at the Russell House, on Monday and Tuesday preceding the meeting, and on Wednesday and the following days at the City Hall and Court House, where the general and sectional sessions will be held, and where the Association will be well accommodated. The citizens of Detroit have formed a large working local committee, comprising nearly two hundred of the leading citizens, with the Governor of the State as Chairman, and we are assured that everything possible will be done to make the meeting a successful one so far as the local arrangements are concerned, while the extraordinary interest taken in the last meeting by the members indicates that the scientific element of the next meeting will be

well sustained. The election of all the important officers a year in advance will not only save much time in organizing the Detroit meeting but will also secure special addresses from the presiding officers of the sections, similar to those which make so important a part of the proceedings of the British Association.

At an early date the Local Committee will issue their circular to members of the Association, giving details relating to the arrangements made for the accommodation of members while in Detroit, and such other information as may be of interest to those intending to be present at the meeting, including any facilities offered by the railroads, reduction of hotel prices, contemplated excursions, etc. In order to receive the circular of the Local Committee without fail, it is desired that all persons now planning to attend the meeting should send their addresses to Frederick Woolfenden, Esq., Secretary of the Local Committee, Detroit.

Professor F. W. Clarke of Cincinnati, appointed by the Chemical Subsection of the Hartford Meeting to notify chemists of the organization of a *Permanent Subsection of Chemistry*, requests that attention be called to the fact that the subsection is a permanent organization, and states that the general interest awakened among the chemists indicates a large gathering at Detroit of those specially interested in that department.

The attention of persons specially interested in Entomology is directed to the action taken by the Entomologists at the Hartford meeting, and to the fact that there will be a meeting of the Entomological Club of the Association at Detroit, on Tuesday, August 10 (the day preceding the meeting of the Association), at which all interested are invited to be present.

It was also suggested at the last meeting that special efforts be made to bring the Ethnologists and Archæologists together at Detroit in order to form a permanent subsection of Anthropology, and it is probable that definite action will be taken on the subject at the coming meeting.

Any person may become a member of the Association upon recommendation in writing by two members or fellows, nomination by the Standing Committee, and election by a majority of the members and fellows present in general session. Blank forms for recommendation to membership, and also copies of the general circular, will be furnished on application to F. W. Putnam, Permanent Secretary, Salem, Mass.

The following are the Officers of the Detroit Meeting:—President, J. E. Hilgard, of Washington; Vice-President, Section A, H. A. Newton, of New Haven; Vice-President, Section B, J. W. Dawson, of Montreal; Chairman of Chemical Subsection, S. W. Johnson, of New Haven; Permanent Secretary, F. W. Putnam, of Salem; General Secretary, S. H. Scudder, of Cambridge; Secretary of Section A, S. P. Langley, of Alleghany, Pa.; Secretary of Section B, N. S. Shaler, of Newport, Ky.; Treasurer, W. S. Vaux, of Philadelphia.

Standing Committee:—Past Presidents, Wm. B. Rogers, of Boston; Joseph Henry, of Washington; Benjamin Peirce, of Cambridge; James D. Dana, of New Haven; James Hall, of Albany; Alexis Caswell, of Providence; Stephen Alexander, of Princeton; Isaac Lea, of Philadelphia; F. A. P. Barnard, of New York; J. S. Newberry, of New York; B. A. Gould, of Boston; T. Sterry Hunt, of Boston; Asa Gray, of Cambridge; J. Lawrence Smith, of Louisville; Joseph Lovering, of Cambridge; the President, Vice-Presidents, Secretaries, and Treasurer of the Detroit Meeting. As Officers of the Hartford Meeting, John L. LeConte, of Philadelphia; C. S. Lyman, of New Haven; A. C. Hamlin, of Bangor; from the Association at large, Six Fellows to be elected on the first day of the meeting.

Local Committee:—Chairman, His Excellency, Governor John J. Bagley; Treasurer, William A. Butler, Esq.; Secretary, Frederick Woolfenden, Esq.; also special sub-committees on Reception, Rooms, Excursions, Entertainment, Printing, etc.

Bulletin No 2, second series of Hayden's geological and geographical Survey of the Territories was issued May 14th by the Department of the Interior. It contains important papers as follows:—I, Monograph of the genus Leucosticte, Swainson; or, Gray-crowned Purple Finches, by Robert Ridgway. II, The cranial and dental characters of Geomydæ, by Dr. Elliott Coues. III, Relations of Insectivorous Mammals, by Theodore Gill. IV, Report on the Natural History of the United States Geological and Geographical Survey of the Territories, 1874, by Ernest Ingersoll.

This was followed on the next day by a third Bulletin, being a "Topographical and Geological Report on the San Juan Country" by A. D. Wilson, the topography illustrated by a map; with a

second topographical report, and a most entertaining narrative it is, by Franklin Rhoda, assistant topographer. This is illustrated by characteristic panoramic views of Mt. Sneffles and adjoining mountains, and of the quartzite peaks seen in looking across the great cañon of the Animas. These reports and two heliotypes of the eroded rocks of Colorado, with an explanatory note by Prof. Hayden, the Geologist in charge, render this a most timely issue, of value to miners.

As a result of the institution of the Anderson School of Natural History at Penikese Island, we are gratified to see the establishment of a similar school in Normal, Illinois.

Arrangements have been completed for a summer meeting of the association of Natural History of Illinois, for the study of botany and zoology, to be held at the museum at Normal, Illinois, commencing July 14th, and continuing until August 11th.

The following gentleman have been engaged as instructors for the term:—Prof. B. G. Wilder, Prof. W. S. Barnard, Ph.D., Prof. T. J. Burrill, Prof. Comstock, and Prof. S. A. Forbes.

It is found necessary to limit the attendance to fifty students; but, within this limit, the class will be open to the teachers of the State. It is desirable that all names should be sent to the committee by the fifteenth of June.

A part of the expenses of the session will be defrayed by a tuition fee of ten dollars for each student; the remainder have already been provided for through the generosity of friends.

The school is to be conducted by the executive committee of the association. We hope to see similar schools forming next year, at least one for each section of the country.

THE Zoological Garden at Philadelphia is rapidly increasing its collection of American and exotic animals. Mr. Goode has recently brought from Florida, according to "The Rod and the Gun," one hundred and thirty-two specimens representing thirty-two species, distributed as follows: mammals, five species; birds, one; lizards, four; serpents, sixteen; turtles, five; amphibians, one. A number of Florida wild hogs have been engaged and negotiations are in progress for some manatees from the Indian River country.

LT. WHEELER'S Progress Report upon geographical and geological explorations and surveys west of the one hundredth meridian

in 1872 has been lately issued. It is a quarto pamphlet of fifty-six pages, and is illustrated with four excellent heliotypes of the striking scenery of the cañon of the Colorado, and with maps, including a progress map of explorations and surveys conducted by the War Department. Appended are reports of the other officers and civilians connected with the survey. We shall look with interest for the appearance of the final report of the survey.

DR. GILL'S "Catalogue of the Fishes of the East Coast of North America" which originally appeared as an Appendix to Prof. Baird's Report on the Fish and Fisheries of the United States, has been republished by the Smithsonian Institution.

THE importation into Finland or any portion of Russian territory of American potatoes, or sacks, cases, or any other articles, which have contained them is prohibited. We suppose on account of the fear of introducing the Colorado potato beetle.

THE "San Diego Lyceum of Natural Sciences" was organized at San Diego Cal., in 1873. The officers for 1875 are Dr. R. J. Gregg, *President*, and George N. Hitchcock, *Secretary*.

"THE Vineland Natural History Club," with about twenty-five members, was organized at Vineland, N. J., March 25, under the Presidency of Mr. D. F. Morrill.

THE "Nebraska Association for the Advancement of Science" has been established at North Platte, Nebraska. I. W. LaMunyon is President, and A. H. Church, Secretary.

DR. JOHN EDWARD GRAY, late keeper of the zoological department of the British Museum, died March 21st, at London, aged 75. He was the leading editor of the "Annals and Magazine of Natural History."

PROF. MARSH has secured for the museum of Yale College, a perfect skeleton of the mastodon lately exhumed at Otisville, Orange Co., N. Y.

PROF. F. V. HAYDEN has been elected a corresponding member of the Geological Society of London.

PROF. CYRUS THOMAS has been appointed State Entomologist Illinois.

THE Anderson School at Penikese has been discontinued for the present season, for want of funds.

THE library of Audubon was destroyed by fire April 29th at Shelbyville, Ky. It was in the house of Mrs. Lucy Bakewell, the sister-in-law of Mr. Audubon. The collection consisted of about eight hundred volumes.

BOOKS RECEIVED.

Twenty-first Annual Report and Abstract of Proceedings of the Brighton and Sussex Natural History Society. Brighton, 1874. pp. 122. 8vo.

Estrada de Ferro do Recife as S. Francisco, Estudos Definitivos de una a Boa-Vista, Executados sob a direccao de J. M. da Silva Coutinho. Rio de Janeiro, 1874. pp. 155. 4to.

Botanical Contributions. By Asa Gray. *Conspectus of the North American Hydrophyllaceæ.* Ex. from Proc. Am. Acad. Arts and Sciences, 1875. pp. 312-332. 8vo.

Contributions to American Botany, V. Revision of the Genus Ceanothus, and Descriptions of New Plants with a Synopsis of the Western Species of Silene. By Sereno Watson. From Proc. Am. Acad. Arts and Sciences. pp. 333-350. 8vo.

Geographical Explorations and Surveys West of the One Hundredth Meridian. Engineer Department, U. S. Army. Systematic Catalogue of Vertebrata of the Eocene of New Mexico, Collected in 1874. Washington, 1875. pp. 37. 8vo.

U. S. Commission of Fish and Fisheries. Commissioner's Report, 1872-73. Washington, 1874. pp. 910. 8vo.

Quarterly Journal of Microscopical Science. London, 1875. No. LVIII. pp. 209. 8vo.

Verhandlungen des Naturforschenden Vereines. Brunn, 1874. xii Band, 1, 2, Heft. 8vo.

Jenaische Zeitschrift fur Naturwissenschaft. Jena, 1875. ix, Bd. N. F. ii, Bd. 1. pp. 132. 8vo.

Proceedings of the Royal Society of Edinburgh. 1873-74, vol. viii, No. 87. pp. 207-414. 8vo.

Archiv fur Anthropologie. Zeitschrift fur Naturgeschichte und Urgeschichte des Menschen. Braunschweig, 1875. Band 7, Nos. 3, 4. pp. 473. 4to.

Catalogue of Lower Silurian Fossils, with Descriptions of some New Species. By U. P. James. Cincinnati, 1875. pp. 8. 8vo.

The Canadian Antiquarian and Numismatic Journal. Montreal, 1875. Vol. 3, No. 4. pp. 145-192. 8vo.

The Influence of Anæsthetics on the Vaso-Motor Centres. By Henry P. Bowditch and Charles Sedgwick Minot. Boston, 1874. pp. 8. 8vo.

Notes on Some of the Phenomena of the Glacial Era and their Origin; in Book Notices. By James D. Dana. pp. 311-317. 8vo.

Memoirs of the Boston Society of Natural History. Vol. II, Part iv. No. 1. *Prodrome of a Monograph of the Tabanidæ of the United States.* Part 1. *The Genera Pangonia, Chrysops, Silvius, Hæmatopota, Diabasis.* By C. R. Osten Sacken. Boston, 1875. pp. 365-397. 4to.

The Oologist. Vol. 1, No. 3. May, 1875, Utica. pp. 17-24. 8vo.

Bulletin de la Societe Geologique de France. 3e Serie, t. III. Paris, 1875, No. 3. 8vo.

Curious Anomaly in History of Certain Larvæ of Acronycta oblinitus, Guenee, and Hints on Phylogeny of Lepidoptera. By Thomas G. Gentry. Proc. Acad. Nat. Sci., Phil. 1875. pp. 24-54. 8vo.

List of the Marine Algæ of the United States, with Notes of New and Imperfectly Known Species. By W. G. Farlow Proc. Am. Acad. Arts and Sciences, 1875. pp. 351-380. 8vo.

First Annual Report of the Geological and Agricultural Survey of Texas. By S. B. Buckley. Houston, 1874. pp. 142. 8vo.

The Recent Origin of Man. By James C. Southall. Philadelphia, Lippincott & Co., 1875. pp. 606. 8vo.

Monograph of the Genus Leucosticte, Swainson; or, Gray-Crowned Finches. By Robert Ridgway. Washington, 1875. pp. 51-82. 8vo.

On Dr. Koch's Evidence with regard to the Cotemporaneity of Man and the Mastodon in Missouri. By James D. Dana. From Am. Journ. Science and Arts. Vol. ix, May, 1875. pp. 335-346. 8vo.

The Diagonal System in the Physical Features of Michigan. By A. Winchell. Am. Journ. Science and Arts, Vol. vi. July, 1873. 8vo.

The Climate of Michigan. By Alexander Winchell. 8vo.

The Isothermals of the Lake Region in North America. By Alexander Winchell. From Proc. Am. Asso. Adv. Science, 1870. pp. 3-13. 8vo.

Syracuse University, Annual Report to the Board of Trustees. By Alexander Winchell, 1874. pp. 17. 8vo.

Michigan. Being Condensed Popular Sketches of the Topography, Climate and Geology of the State. With Charts. By Alexander Winchell, 1873. pp. 121. 8vo.

Religious Ideas Among Barbarous Tribes. 1. Facts. By Alexander Winchell. From Methodist Quarterly Review, Jan., 1875. pp. 5-27. 8vo.

The Unity of the Physical World. II. Facts of Succession. By Alexander Winchell. From Methodist Quarterly Review, Jan., 1874. 8vo.

Revue Scientifique de la France et de l'Etranger. No. 44, 1er mai, 1875. Quartrieme annee, 2e Serie.

Descriptions of Two New Species of Birds of the Families Tanagridæ and Tyrannidæ. By Geo. N. Lawrence. Annals Lyceum Nat. Hist., N. Y., Vol. xi, 1874. pp. 70-72. 8vo.

Descriptions of Four New Species of Birds from Costa Rica. By Geo. N. Lawrence. Annals Lyceum Nat. Hist., N. Y., Vol. xi, 1875. pp. 88-91. 8vo.

The Entomologist's Monthly Magazine. Vol. xi, London, May, 1875. 8vo.

Report of Progress of the Mineralogical, Geological and Physical Survey of the State of Georgia. For the period from Sept. 1, to Dec. 31, 1874. pp. 36. 8vo.

Bulletin of the U. S. Geological and Geographical Survey of the Territories. F. V. Hayden in charge. Second Series, Bulletin, No. 2, 3, 1875. 8vo.

THE

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THE VEGETATION OF THE ILLINOIS LOWLANDS.

BY PROF. GEO. H. PERKINS.

THE vegetable life of Illinois presents many points of general interest, and these are nowhere else so prominent or peculiar as over the broad, level tracks of moist land so often bordering the large streams of the West. These lowlands or, as locally termed, "bottom lands" or "river bottoms," are of very variable extent, their limits being determined for each stream by the character of the region through which it takes its course. In one part of the river they are many rods in width and follow it for miles; in another they are narrow and soon end, and again they are wholly wanting, as when bluffs come to the water's edge and form rocky or gravelly banks. This is finely illustrated in Northern Illinois, where along the Mississippi are high banks with many an outcropping cliff of Galena or Niagara limestone. These cliffs have weathered into forms so strangely like half-ruined fortresses that it is not easy to believe that yonder bit of wall, half concealed by vines and shrubs, this crumbling turret, or those broken battlements, are but rough masses of rock. In passing from the extreme northern part of the state southward, we find the hilly, uneven surface growing smoother and more like a rolling prairie, which it finally becomes, and this in turn giving place to the dead

level of the flat prairie; yet the greater part of the northern third of the state is far from level, and the river bottoms, though often extending one or two, and in some places, five miles from the Mississippi, are not infrequently broken up by highlands. Nearer the centre of the state these lowlands are wider and less interrupted in their extent. From Rock Island to Quincy, and even still farther south, for a distance of over two hundred miles, bluffs do not form the shores of the Mississippi, except at intervals widely separated and for short distances. In many places the banks are formed simply of the washed out edges of great prairies that extend for many miles into the state. Often while the banks themselves are low, at varying distances from the water the ground rises in rounded hillocks or ridges, or masses of limestone jut out above the surface and form sharp cliffs, all known under the general name "bluff." Between the bluffs and the river the ground is generally low, moist and often swampy. Such lowlands along the great river are from a few rods to ten miles in width and, of course, many more in length. Similar, though less extensive lowlands, are found along Rock River, Illinois River and other lesser streams, and along the Iowa side of the Mississippi. Not all of these river bottoms are swampy, some are reached only by unusually great freshets and are very valuable as farm lands, the soil being the richest loam, others, but little elevated above the usual level of the water, are overflowed by every rise and may be not only swampy but dotted here and there with ponds, some of which are of quite large size. Sometimes these ponds unite, retain a permanent connection with the stream and, at low water, flow towards it with a slow current, forming what are called "running sloughs." Wherever the lowlands are flooded only at long intervals, or only every spring, when the stream is at its highest level, they are usually covered with forests which are made up of trees of large size and are singularly free from undergrowth. In midsummer, after the spring floods, when the ground has dried, a carriage may be driven through these forests for miles with very little inconvenience from bushes, or indeed from any obstacle. It is not easy to imagine such forests as ever formed of *young* trees, they seem to have always been large and old and stately as now. True temples of nature are they — the ground smooth and turf-covered as if carefully prepared for crowds of worshippers — the

grandly rugged columns of oak, maple, cottonwood, sycamore and many others, reaching far up to the leafy arches of the roof—the profound silence brooding over all, call the soul to humble adoration of the great Father of all. Except the occasional chatter of a squirrel, the tremulous, half frightened twitter of a bird, or the monotonous hum of an insect, scarce a sound is heard above the rustling of leaves, murmur of wind, or creaking of interlocking branches, sounds all of them only serving to make the silence seem the more profound. Undevout and inappreciative indeed must be the heart that can resist the sombre fascination of such a place, a place where, away from life's cares and vexations, away from human influences, surrounded by majestic trees, whose huge trunks by their ribbed and seamed sides tell of centuries of growth, while their tops, green and leafy, declare that the mystery of life and growth still goes on with unabated vigor, is found closest communion and fullest sympathy with nature. But there are broad tracts too wet to afford a suitable soil for the growth of forests. In such places only groves or belts of woodland are found. These cover the higher portions of land, while all around are wide marshes covered with tall reeds, sedges and grasses, and lowest parts filled by ponds.

After the high water of spring has subsided, the ponds are bordered by a belt of mud or sand, over which crawl hosts of Paludinas, Lymnæas, Physas, and other "snails," while just below the water's edge the more strictly aquatic Unios, Anodontas, Planorbis and the like are equally abundant, so that these places offer great attractions to the conchologist.

Although I have collected fresh water shells in many localities, I have never secured so rich a harvest of some of the larger species as in some of these sloughs. And specimens are not only abundant, but of large size and with unusually bright colors. Nor are these localities less inviting to the ornithologist. Quite a number of species of birds find in them a congenial home and abundant food, ducks in the water, and plovers, herons and the like along the margins of the ponds, and in the rank growth of sedges and grasses, or the copses of button-bush which afford them shelter, many a thrush and warbler, while over all, like an untoward fate, hovers the bird of prey. Passing these attractions, interesting as they are, without further notice, let us now devote

ourselves to a study of the botanical characteristics of the region. From early summer until late autumn many a rare and beautiful flower is here seen. Perhaps the finest display is in late summer, when, over the higher borders of the marshes, where the lowland rises to meet the upland prairie, grow hosts of purple phloxes, mints, pentstemons and many other species, while here and there, towering high over all the rest, are seen superb clusters of the rose-pink *Spiræa lobata*, well called "queen of the prairie." On lower ground and in more moist soil, are several species of gerardia with rose-purple flowers, some of the more delicate being exceedingly graceful, the whole plant covered with beautifully tinted flowers, being an airy panicle of bloom. Other species with yellow flowers and of less graceful habit are found on drier ground. With these charming plants are found blue lobelias, purplish or blue veronicas, white chelone and a large representation of polygonums or knot-grasses, with flowers of crimson, rose, white or greenish hues, most of them neither very attractive nor conspicuous individually, but when growing in masses the effect is often very pleasing, and in the case of *Polygonum amphibium* even brilliant, its deep crimson wands making many a pool bright and beautiful. Much taller than these are the umbelliferæ, some species of which rival small trees in size, the white flower clusters standing seven or eight feet above the ground. Not infrequently from some darker, shadier nook flashes the brilliant red of the cardinal flower, while just above the smaller herbs, sometimes like a cloud of variegated mist, wave the panicles of purplish, yellowish or greenish grasses and sedges, the light green of the wild rice being often especially noticeable. In the water, besides many of the grasses and sedges, are found pennywort, several species of ranunculus, sagittaria, pontederia, lemna, azolla, peltandra, beautiful pond lilies, which seem to attain their largest size in this region, and many other plants of similar habit. Among these smaller species, or by itself alone, grows the great nelumbium, giant among our aquatic plants, of interest because of its kinship with the Egyptian lotus. This covers many acres, often extending for several miles in great patches. The large cream-colored corollas, standing often five or six feet above the water, are very conspicuous and attractive, as are also the leaves, their great disks, one to two feet in diameter, lying on the surface of the

water or raised somewhat above it. The upper surface of these leaves is of the most exquisitely shaded, velvety green, with which the much lighter shade of the under side contrasts in a most pleasing manner. In the fall the flowers give place to the huge conical seed cases, holding in cup-like depressions on the flat upper surface acorn-like seeds, which, in days gone by, furnished an important article of food to the Indians. Not infrequently small flocks of ducks are seen leisurely filing in graceful curves in and out of this lily forest, and more rarely a solitary blue or white heron stands dreamily gazing into the water, or lazily wings his way to the distant wood. But few song-birds are found in midsummer in the immediate vicinity of the large ponds, though more common a little way from them, and often the silence is almost as complete here as in the great forests, the only sounds, perhaps, being the harsh call of a hawk or the sudden splash of a water rat or large turtle. If a knoll or other elevated position can be gained a wild scene often lies before the observer. All around him as far as the eye can reach lies the seemingly boundless sea of waving grass, the undulating surface only interrupted now and then by rounded clumps of the glossy-leaved button-bush (*Cephalanthus*), or more rarely by the tall form of a cotton-wood or other tree, while in the far distance the sky meets the moving surface, or a belt of trees forms a dark wall which limits the view, except where there are breaks through which are glimpses of the same billowy expanse stretching on and on indefinitely.

The state of Illinois extends from north to south over three hundred and eighty miles, and for this reason would naturally be expected to produce a very varied flora, as it certainly does both as to tree and herb.

In one of his works Humboldt mentions the tropical appearance of the forests of the Mississippi valley, due to the frequent occurrence of pinnate-leaved trees, and the palmate-leaved trees add greatly to the same effect.

In many of the forests there is a very noticeable absence of the higher cryptogams, such as ferns, club-mosses and mosses. Occasionally a great profusion of these plants is seen, but often one may ride for hours through rich, damp woods without seeing altogether more ferns than could easily be held in the hand, and the bright, rich green of mossy bank or moss-covered rock or log is not

often seen. It is not improbable that the germs, or young plants of these tribes are washed away and destroyed by the often recurring freshets, especially by the spring floods, but they are absent not only from the lowland forests, but as well from those on the uplands where no freshet ever comes. Here the drouth of summer may destroy them as too much moisture does in the lowlands. If we study the trees alone we find that the entire state affords not far from a hundred distinct species and varieties, besides about one-fourth as many shrubs. It would be out of the question to mention more than a few of the more important species here. Of the maples, the sugar and the silver, or white, are abundant, and of large size, sometimes reaching a height of a hundred and fifty feet and a diameter of eight or ten feet.

The red maple so common in New England very rarely occurs wild in Illinois, so far as I can ascertain. The oaks are represented by at least fifteen species and varieties, and in many places form the greater part of the forests and in new settlements they furnish most of the building material in place of the lacking pine and spruce. Of this tribe the most abundant and widely distributed are the white, red, and black oaks. The bur, swamp and post oaks, are common in some localities, as are the pin oak, chestnut oak and laurel oak, though they do not seem to be as universally common over the state as the three species first named. The scarlet oak and Spanish oak are probably the least common, except Lea's oak which occurs in Fulton county and perhaps elsewhere. Both species of Nyssa found in the Northern States are common in Southern Illinois but not elsewhere. The pawpaw, persimmon and pecan are found more or less abundantly over the southern two-thirds of the state, the first species occurring as a second growth sometimes in considerable quantity. There are several species of trees which are found either alone or in small groups or along the edges of groves, but they very rarely form groves by themselves. Those of this class which are most commonly found upon moist ground are, the honey locust, beautiful in form and foliage, at a distance one of the most attractive of trees, but hideous often for its huge clusters of thorns; the box-elder, or ash-leaved maple, with drooping branches that in large, solitary trees sometimes almost touch the ground, and in one or two such specimens I have seen almost perfectly regular domes, the base of

each nearly touching the ground; the buckeyes, which are very beautiful trees, the black walnut, butternut, and larger than any of those mentioned, rivalling the very largest of all our trees, the sycamore and tulip-trees, and more rarely in the southern part of the state two small trees, the two species of *Bumelia* or southern buckthorn. Besides the maples and oaks some of the largest trees found in Illinois are the cotton-wood, linden, red, green, blue, white and black ash, wild cherry, the various species of *Carya*, the American and red elm and some others. Many of these trees are found of very much larger size than is common in our New England forests, especially such as grow on the bottom lands. Here maples, sycamores, cottonwoods, etc., from a hundred to a hundred and fifty feet in height, and six to ten feet diameter at the ground are not uncommon, and now and then these dimensions are considerably exceeded. Even the sassafras, which in New England is a small tree, sometimes grows to a height of seventy feet. This species I have seen spring up as a second growth and so completely cover several acres as to exclude almost every other tree or shrub. The willows are well represented all over the state, though I have never seen them covering very wide tracts, as in some parts of the country. Both on the lowlands along the borders of small streams, and on the upland prairies the wild plum is common, and in similar localities clumps of wild apple are found. Both of these trees are very beautiful when in bloom, especially when together, the pure white of the plum and the pink of the apple blending finely while the delicious fragrance of the latter perfumes the air far and near. The birch, so commonly found in New England woods, is rarely found in Illinois, and only one species, the red birch, is found at all. Evergreens, which constitute so marked a feature in many landscapes, are often wholly wanting in Illinois scenery. The red cedar is found sparingly in many parts of the state, and on rocky ridges in the Northern counties the white cedar grows. Sometimes, too, the white pine and dwarf juniper are seen. One more species completes the list of coniferæ, the bald cypress, which grows along the Ohio and Mississippi, in the Southern counties where it occupies great swamps, its straight trunk towering for a hundred and fifty feet above the ground. This tree is very valuable for timber, though from its habits and

place of growth it is not as easily obtained in large quantities as trees growing in drier soil, and without its sometimes almost impassible barricade of roots, arching and twisting above the surface of the swamp, and amid these the massive trunks of fallen trees.

Grand indeed are many of these old trees in their rugged bark and the green and gray of moss and lichen, while some are not only grand but very beautiful as they are overhung with delicate or heavy arabesques of clinging vines that sometimes hide completely the rudeness of their support, and sometimes but partly cover it, while making that which is not concealed all the ruder as it contrasts with their own grace. There are many more species of twining plants and vines growing wild in Illinois than in New England, and, as with the trees, so with the vines, our familiar friends are so large and luxuriant that we scarcely recognize them. The poison ivy, Virginia creeper, or woodbine, and wild grape are all found there and are largest of the vines. They often completely cover, not only the shaft of a tree, but its top as well, sometimes so tightly embracing their support as to destroy it. They reach the very top of the highest trees, and are found with stems a foot or more in diameter near the ground. Not always do these climbers cover and destroy green and living trees, often their fullest beauty is reached as they drape the naked, seared trunk from which life has long since gone, thus changing the unsightly and uncouth into noble shafts of living green. Besides these giant vines there are many smaller and more delicate. Some of these, as the wild yam, moonseed, hop, four or five species of smilax, or greenbrier, and other allied forms which are beautiful for the green of their foliage and attractive mode of growth, but with inconspicuous flowers, fill many a thicket with masses of tangled cords. Others have the double beauty of foliage and flowers, the grace of pendant branch and twining stem being completed in the more splendid charm of clusters of flowers. Chief of these, as it is chief of all our native vines, is the Wistaria, found native in Southern Illinois. Superb is this vine when of large size and in the full glory of bloom, the large clusters of rich purple flowers hanging thickly over the soft green of the leaves. Yet more showy, though less elegant, is the Bignonia, or trumpet creeper, as its clusters of orange buds and flowers gleam like some bright

fruit from amid the branches of a tall tree or, unexpectedly flash out from the interlacing branches of the thickets in which it loves so well to grow. Less showy climbers and of smaller size are several species of clematis, the wild passion-flower, cypress, morning-glory, and all the rest, each with its own peculiar beauty of flower or leaf, sometimes growing alone, sometimes intertwined about the same tree with several others, uniting their various hues, the charms of each brightened by those of the others and all forming a variegated, harmoniously tinted mass delightful to see. In the dreamy midsummer when all nature's influences incline to reverie and repose, no place can be more fascinating than the wild regions of which we have been speaking. More than elsewhere in the shaded walks of the ancient forests, is there a coolness and freshness most grateful to the body, and a freedom from care, a retirement and a restfulness, as grateful and soothing to the mind. Not those who have flitted hither and thither over the railroads of the West, not even those who have sailed on its great rivers, have an adequate idea of the peculiar modes in which nature expresses herself in those regions, but only to those who have, alone and on foot, wandered for miles and miles amid the forests, over the plains, through the marshes, held by the love of nature, is it given to know her in her friendliest moods.

THE POTTERY OF THE MOUND BUILDERS.

BY F. W. PUTNAM.

[Concluded from June Number.]

Nos. 7759, 7760, 7787, 7788, 7789, 7790, 7791 and 7792 are water jars of various sizes and shapes, as shown in the four figures illustrating this group. 7759 differs from the others by being constricted in its upper portion. The neck of this jar is not preserved, but was probably like the restoration given in the figure. The diameter of greatest bulge of this vessel is from 6 to 6·2 inches. The constricted portion is about 3·3 in diameter, and the upper bulge is ·5 of an inch more than the constricted part. The present height (without the neck) is 5·5 inches.

No. 7786 is remarkable for its flatness, the whole jar being 6·8 in height, but one-half of this is in the length of the neck. This jar is also much flatter at its base than any of the others,

No. 7759.

and has its greatest diameter 2·5 inches from the bottom where it measures 6 inches. The upper part of the neck is 2·3 inches in diameter.

No. 7787 is the most perfect in finish and symmetrical in form,

No. 7787.

No. 7788.

with a small sized neck. This jar is 8·3 in height, and has its greatest diameter 6·4 inches from the bottom.

No. 7788 has a diameter of 7 inches and is 8·5 inches high. No. 7790 is 6·5 high by about 4·9 in diameter. No. 7792 is the smallest and most rudely made: it is 3·5 high by 2·9 in diameter. Its neck is 1·8 long and the diameter of the mouth is about 1 inch. Nos. 7739, 7740, 7753, 7757, 7758, 7793, 7794, 7795, 7796, 7797, 7798, 7799 are all spherical vessels with short necks and moderately sized mouths and are of various sizes. Nos. 7753, 7795, and 7798 are figured and show the variation in the pattern.

No. 7792.

No. 7753 differs from the rest in having been colored red, and in having the bulging portion slightly indented so as to divide the sides into four slightly marked portions.

No. 7753.

No. 7740.

This vessel is 3·3 inches high, 4 inches in its greatest diameter, and 2·4 across the mouth which has a slightly turned lip.

No. 7740 is of similar shape and size to this, but has the surface divided into six projections instead of four. The lips of this are broken.

No. 7798 is not as well made as the others, the clay not hav-

No. 7795.

No. 7798.

ing been so well burned, and it is lighter in color, probably from

that fact. It is one of the smallest of the collection and the neck is without a turned lip. It is 3·6 inches in height by 3·4 in diameter.

No. 7795 is a nearly symmetrical vessel, made of the fine clay of which many of the articles are composed. It is 6·8 to 6·9 inches in its greatest diameter, 6·9 inches high, and 3·4 across the mouth. This vessel is slightly flattened at its base.

No. 7794 is the largest of the series, and is from 8·1 to 8·3 in diameter by 7·8 inches in height.

Nos. 7741, 7742, 7752 and 7754 are small vessels of the shape shown in the figures. 7742 might, from its finish and shape, be well classed as a drinking cup. It is 2·9 inches in height by 3·6 in greatest diameter, and about 3 inches across the mouth, the lip of which is slightly ornamented by small oblique lines cut in its inner border.

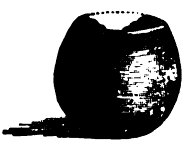
No. 7741.

No. 7742.

No. 7741 is not as symmetrical a vessel as the last mentioned, and has considerably thicker walls. It is about 3·6 inches high and about 5·3 in diameter with an uneven mouth about 3·5 inches across.

No. 7754 is a roughly made little cup, quite thick and only partially baked, about 2·6 inches high and with its greatest diameter equal to the height.

No. 7752.



No. 7754.

No. 7752 is another small cup about the size of 7754 but more spherical in shape and having a hole near its mouth, as shown in the figure. The opposite portion of the mouth is broken, but it is probable that a corresponding hole existed there, and that these

holes were for the purpose of suspending the cup. This perforated cup naturally leads to the next group of vessels, or pots with handles, of which class there are several of various sizes, with slight variation in finish and ornamentation.

Nos. 7763, 7778 and 7780 are the three largest pots, and are without ornamentation. Nos. 7763, and 7778 have the surface divided into six even portions by slight depressions. Nos. 7780 and a smaller pot, No. 7779, are perfectly plain and with even surfaces. No. 7767 is a smaller pot, of the character of 7763, with its surface divided into six portions. No. 7769 is a small vessel,

No. 7767.

No. 7770.

smooth on its sides, but with its lips marked by small oblique lines cut in the clay. No. 7770 is ornamented by a row of small depressions, as if made with a pointed stick while the clay was soft. No. 7771 is a little more elaborate in its ornamentation, the punctures extending down the sides in groups which are enclosed in lines cut into the clay. By the side of the figure of this pot is placed a figure of one of somewhat similar ornamentation, but which does not seem to be now with the collection, unless in fragments.

No. 7771.

No. 7800 is a large pot (now in fragments) ornamented in a

similar manner, but with the addition of small bunches of clay forming the bases from which the ornamental arches are sprung.

No. 7800.

The design on this vessel is carried out quite symmetrically.

No. 7772.

No. 7772 was evidently designed to represent the face of some animal in relief on one side of the pot, as shown in the figure; a portion of this face is on a missing fragment. The distance between the handles on the opposite side is marked off by four arches of double lines.

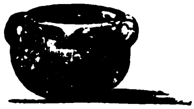
Nos. 7762, 7765 and 7766 are plain pots with four handles like

No. 7762.

No. 7773, and others from the Big Mound. No. 7766 is the smallest pot in the collection. No. 7765 is remarkably thick and heavy, weighing 2 pounds and 14 ounces, while 7762, of very nearly the same size, weighs but 1 pound 15 ounces.

No. 7768 is a small pot with eight handles. These handles extend from the lip to a projecting ridge round the pot as shown in

No. 7766.



No. 7768.

the figure, and this ridge is ornamented by vertical lines, evidently made with the thumb nail while the clay was soft.

The following table gives the dimensions of these several varieties of pots with handles:

No.	7763.	Height	6	inches;	greatest	diameter	8	inches.
"	7762.	"	5·8	"	"	"	7·7	"
"	7765.	"	6	"	"	"	7·3	"
"	7800.	"	6	"	"	"	8	"
"	7780.	"	4·1	"	"	"	6	"
"	7778.	"	4·2	"	"	"	6·1	"
"	7768.	"	3·6	"	"	"	4·6	"
"	7769.	"	3·6	"	"	"	4·6	"
"	7772.	"	3·7	"	"	"	4·4	"
"	7767.	"	3·2	"	"	"	4·6	"
"	7771.	"	3·2	"	"	"	4·2	"
"	7770.	"	3·2	"	"	"	4·3	"
"	7779.	"	3·2	"	"	"	4·4	"
"	7766.	"	2	"	"	"	2·7	"

No. 7777 is a vessel transitionary in form between the pots with two handles and the wide open vessels with two knobs. It agrees with the pots like No. 7800 in shape, but is provided with two flanges or knobs from the lip like No. 7715. It is four inches high, 5·8 in diameter at its bulging portion and four inches across its mouth.

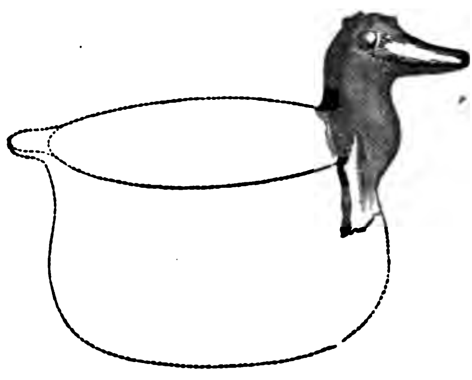
Nos. 7715, 7720, 7733 and 7737 are all of the same character, but of various sizes and depths, and are of solid make. No. 7715 is the best finished and most symmetrical of the lot, and also the smallest, being but 2·4 inches in depth by 3·6 in diameter across its mouth which is its widest part. No. 7733 is 2 inches high and 4·5 in diameter. No. 7720 is 2·7 high by 4·6 in diameter. No. 7737 is of the same height as the last, but measures 5·2 in diameter.

No. 7715.

No. 7717.

Of the same character of vessels with those last described are the "head dishes," in which one of the knobs is made in the form of the head of some animal, or represents the human head, more or less perfectly moulded in the clay. No. 7717 is the most rude attempt to represent a bird's head, and is similar to that from the Big Mound figured under No. 7824. Nos. 7714, 7718 and 7719 are unmistakable representations of the heads of ducks. No. 7723 has

No. 7814.



the head of some animal with large ears, and differs in shape from the others in having the sides of the vessel turned inward

at the mouth, while all the others are wider at the mouth than in any other part. Of 7716 and 7818 only the heads are now

No. 7718.

preserved (unless the rest of the vesse!s are among the fragments that have not yet been restored). No. 7730 has a well

No. 7719.

No. 7723.

designed human head which was evidently made in two pieces and put together before the vessel was baked. In this the hair

No. 7716.

No. 7818.

is represented as carried over the top of the head and down its back in the form of a narrow braid. The eyes, mouth and ears are perforated so as to open into the hollow of the head. It will

be noticed that in all the instances where the human head is represented the face looks into the dish while all the birds' heads, and the head of the mammal, look outwards. (No. 7717 has the appearance of looking into the dish, but this rude head has a

No. 7730.

portion broken from the outside which probably would have better represented the bill of a bird pointed that way.)

The several most perfect of these head dishes measure as follows, the first figure representing the height, and the second, the diameter, across the opening: No. 7730, 4·7 by 9 inches; No. 7718, 3·8 by 8·5 inches; No. 7717, 3·5 by 7·6 inches; No. 7719, 4·2 by 7·6 inches; No. 7716, 3·2 by 6·8 inches; No. 7743, 3·1 by 7·8 inches; No. 7723, 3·1 by 3·5 inches.

Col. Foster, on p. 246 of his work (reproduced here on p. 407), figures a "drinking cup" from a stone grave in Perry County, Mo. This cup is of the same design and pattern as No. 7730, and it may not be venturing too much if we conclude, from this very peculiar form of pottery, that the same race made the article found in the ancient cemetery of Perry County and those found in the mound in New Madrid in the same State. If this should be substantiated by further evidence we shall have the means of identifying the general cemeteries of the moundbuilders, or, at least, of that particular race who erected the mounds of the southwest. It has long been urged that the moundbuilders must have had other depositories for their dead than the mounds themselves, for, as numerous as the latter are, they do not often contain more than

one or two burials and hence they are not sufficient in number to serve as the only places of burial used by the race which must have been so great in numbers.

Nos. 7731 and 7732 are two very interesting circular dishes with low bulging sides, on two opposite portions of which the front and hind parts of animals are represented in relief, the wide mouths of the dishes occupying the position of the backs of the animals. No. 7731 has the projecting and upward turned head of a turtle with the front legs on its sides, while the hind legs are represented on the opposite portion. This dish is 2·9 high and 4·5 inches in diameter across the opening. No. 7732 is 3·7 inches high by 4 inches in diameter, and has a representation of a frog as the other has that of a turtle. Nos. 7817 and 7821 are probably portions of similar dishes representing other animals.

No. 7735.

Nos. 7735 and 7736 are circular shallow dishes with rounded sides. No. 7735 is 4 inches high by 6·4 in diameter across its mouth. The outside of the edge of this dish is ornamented by notches cut in the clay. No. 7736 is 5·4 in diameter and 3·3 high. It has the sides more rounded towards the mouth than is the case with the other, and has two deeply cut grooves around its open margin.

No. 7736.

No. 7746 is a very thin and symmetrical dish, nearly flat on its bottom, with flanging sides. It is 3 inches in height by 5·1 inches in diameter, and without ornamentation. No. 7724 is a larger dish of similar shape, but thicker. The height is the same as the last, but its diameter is 8·2 inches.

No. 7746.

Nos. 7721, 7722, 7725, 7726 and 7734

are basin-shaped dishes of various sizes and with slightly ornamented edges, as shown in the three figures.

No. 7722.

No. 7726.

No. 7725.

No.	7721	is	8·4	inches	in	diameter	by	3	inches	in	height.
"	7722	"	9·8	"	"	"	"	5	"	"	"
"	7725	"	8·7	"	"	"	"	3·7	"	"	"
"	7726	"	7·6	"	"	"	"	2·7	"	"	"
"	7734	"	5·1	"	"	"	"	1·8	"	"	"

No. 7728 is a similar dish, but without ornament on its edges, and is 7·2 in diameter by 3·5 in height.

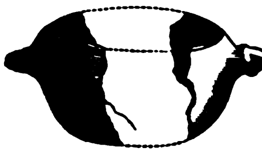
Nos. 7727, 29, 38 and 44 are saucer-shaped dishes, perfectly plain and all about 2·5 inches in height and of the following diameters, 6·8, 7·8, 8, 8·1 inches.

The last perfect specimen of these interesting earthen vessels from this mound is the peculiar cup here figured under No. 7756. It is 2·4 inches high and 2·5 in diameter across its top, by 1·6 inches across its flat base. Its concave portion is ·6 of an inch in its centre. This singular article has the appearance of having been worked into its shape entirely by pinching out a mass of plastic clay with the fingers, and it seems to have been hardened by fire only in its cavity, as if hot coals had been held in it.

No. 7756.

No. 7815 is in fragments, but the figure conveys an idea of its character.

No. 7815.



Among the numerous fragments of vessels of various shapes, the following are specially interesting: No. 7828, portions of a small vessel that stood on three short spherical hollow legs. This vessel is ornamented with stripes of red. No. 7755 is, probably, a leg of a similar vessel but of a larger size and not colored. No. 7826 consists of fragments of shallow dishes, colored red. Nos. 7802 and 7808, probably portions of the same vessel, represent a pot, of about the shape of No. 7762, that had evidently been used to hold the red paint with which several of the articles were colored.

This last cut was received with the collection, but the vessel which it represents is either among the fragments and beyond recognition or was not received with the rest of the specimens.

Prof. Swallow concludes his account of the mounds he examined about New Madrid as follows:—

"These mounds appear very ancient. Soil has formed on them to the depth of three feet. The largest trees grow on them and the connected embankments, or levees.

"A sycamore twenty-eight feet in circumference three feet above the ground, a black walnut twenty-six feet in circumference, a *Quercus falcata* seventeen feet, a white ash twelve feet, and a chestnut oak eleven feet in circumference were observed on these mounds and accompanying embankments.

"The six feet of stratified sands and clays formed around the mounds since they were deserted, the mastodon's tooth found in these strata, and other facts indicate great age. These six feet of thin strata were formed after the mounds, and before the three feet of soil resting alike on the mounds and on these strata.

"There are numerous mounds in this Swamp country. I saw one in Pemiscot county thirty-five feet high, elliptical (longer axis N. and S.), one hundred and ninety-five feet long on top and one hundred and fifty feet wide. This mound is part of a large system of

earthworks; there is a square about one thousand feet on each side surrounded with a line of earthworks or embankments several feet high, and the whole area is filled in about ten feet. In the area are two mounds, the one above mentioned and another smaller, fifteen feet high. There are also several basins in the area, circular and much depressed, and a canal on the south side of the square, fifty feet wide and twelve feet deep. The large mound mentioned was cracked open by the earthquake, as was very obvious when I visited it.

"Col. J. H. Walker, who was a youth of sixteen years at the time of the earthquake, showed me the mound in 1856, and also many large cracks produced by the earthquake. One of these cracks ran through this large mound. Col. Walker told me:—This crack was opened by the severe shock of Dec. 11, 1811. It made a wide gap through the mound from top to bottom. He [Walker] went into it and saw at bottom about twenty feet of bones, some human, some fish, and some of other animals. Above the bones was a coat of plastering made of clay, cane and grass from five to thirteen inches in thickness. Col. Walker was a leading man in that country, well known all over the state, and was deemed very reliable."

From Foster, page 246.

"Drinking Cup," one-fourth natural size, from Cemetery in Perry Co., Mo.

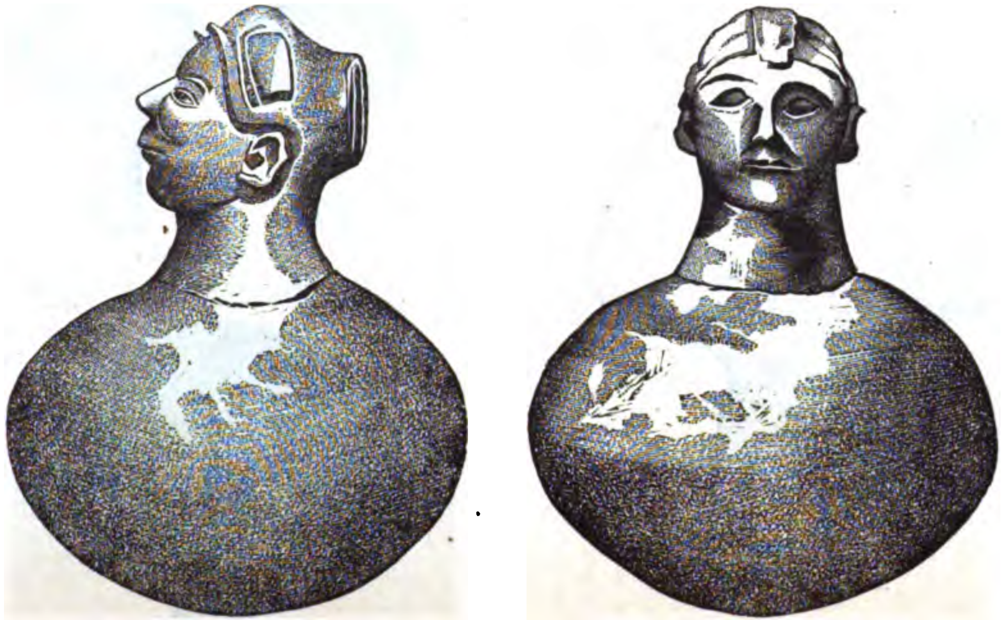
From Foster, p. 237.

"Water-coolers, eight inches high, from Cemetery in Perry Co., Mo.

From Foster, p. 243.

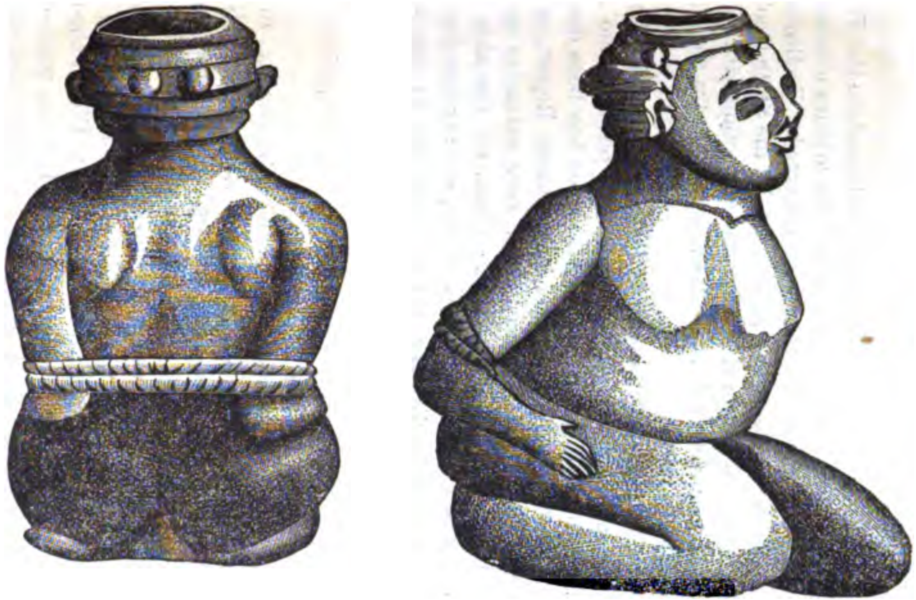
"Water-jug," one-half natural size, from near the mouth of the Wabash.

From Foster, p. 239.



"Water-Jugs," eight and one-half inches high, from a mound near Belmont, Mo.

From Foster, p. 240.



"Statuette" eight inches high from a mound near Belmont, Mo.

ARCHÆOLOGICAL EXPLORATIONS IN INDIANA AND KENTUCKY.[1]

BY F. W. PUTNAM.

THE following abstract of a special Report, made to the Trustees of the Museum conveys a general idea of the articles obtained and the conditions under which they were collected. Facilities were extended, in the explorations in Indiana, by the State Geologist, Professor Cox. While in Kentucky my connection with the Geological Survey, under Professor Shaler, secured extra facilities for the explorations there.

Several stone implements were collected from within the walls of the ancient stone and earth fortification on the Ohio River, near Charlestown, Indiana. This fortification has been described in detail by Professor Cox in his last Annual Report as State Geologist of Indiana, and consists of very extensive walls of stone laid without cement. At one place, on the side facing Fourteen Mile Creek, the wall is about seventy-five feet high, extending for some distance and filling a gap in the natural precipice on that side. Several fragments of flint arrowpoints were picked up within this enclosure, and Capt. Sam. C. Rucker, who lives near the fort, presented me with a few perfect implements he had found within the walls.

Another similar fortification was examined at Deputy, Indiana, and will be fully described by Professor Cox, in his next Report. The principal wall here was several hundred feet in length and was doubtless, originally, several feet in height. A singular stone mound, or monument, was also examined near Lexington, Indiana, but nothing that could be brought away was found at either of these last mentioned places. A large Refuse Circle, about four hundred feet in diameter, near Lexington, Indiana, proved to be unlike anything I had seen before, and from the abundance of split bones of animals, fragments of pottery, etc., found in the narrow ridge forming the circle, one can but consider this ridge as forming the outline (perhaps the inside of a stockade) of an

[1] Reprinted from the 8th Report of the Trustees of the Peabody Museum of American Archæology and Ethnology, 1875.

ancient camp. Fragments of pottery, with bones of deer and other animals, were collected.

Numerous stone implements of various kinds, found about Charlestown, Indiana, were secured. Several of these were kindly given me by Mr. F. M. Runyan, of Charlestown.

A collection of stone implements was made at Grayson Springs, Kentucky, and vicinity. One very interesting moundbuilder's implement of the class generally known as "plumb-bobs," and made of magnetic iron, beautifully polished, was given to me by Mr. Chas. J. Adams of Grayson, though it was said to have been found "in a coal mine" on Green River. To Mr. Adams I am also indebted for several other stone implements from various localities.

The most important exploration in Grayson County, Kentucky, was that of the Rock Shelter near Grayson Springs. This was an overhanging ledge of rock, and on the shelves of rock and in the soil below them, were found several bones of animals, as well as a few flints, fragments of pottery, charcoal, etc., and two mortar holes were noticed cut in the solid rock. A large number of bones from this place are interesting in showing the manner in which they have been gnawed by rodents.

Several caves in the vicinity of the Mammoth Cave were explored, and important results obtained. So little is known of the use of caves in the United States, either for purposes of burial or as habitations, that every opportunity was taken for their exploration.

Sanders' Cave in Barren County, Haunted Cave in Edmonson County, and a dry (unnamed) Cave in Hart County, are probably to be classed only as burial caves. Of these, Haunted and the dry Caves had been much disturbed, and many human bones had been carried away by the residents in the vicinity. Haunted Cave had also received attention from other members of the Kentucky State Geological Survey, earlier in the year; still a number of human bones and two crania were obtained from these two caves in which the bodies had been buried with care. In Sanders' Cave (owing to its difficult entrance this cave has seldom been visited) many skeletons are to be found, but the cave has received the washings of a farm, and its filthy and wet condition renders investigation rather unpleasant, and the bones hard to secure in a perfect state. In this cave the bodies seem to have been placed at one time, and from two stone arrowheads, found among

the ribs of one of the skeletons obtained, there is some ground for the belief that it may have been the burial place of the victims of a battle on this "dark and bloody ground." Further study of the crania, however, will be necessary in order to determine the race to which they belong. Several crania, a number of other parts of human skeletons, and numerous bones of animals were obtained from this cave. The crania are all of the same character, having quite flat frontal bones and a deep depression just back of the coronal suture, and they are quite different from those of the dry caves, which are high and full in the frontal region. The tibiæ in both lots show various degrees of flattening.

That some of the caves were used as places of, at least, temporary residence, was conclusively shown by my exploration of Salt Cave, which proves important in revealing a new phase in American archæology. This cave, in many respects, approaches the Mammoth Cave in the size of its avenues and chambers. Throughout one of the principal avenues, for several miles, were to be traced the ancient fire-places both for hearths and lights. For the latter purpose, small piles of stones were made with a hole in the centre of the pile to receive the bundle of dried fagots perhaps smeared with grease. Bundles of these fagots, tied up with twisted bark, were found in several places in the cave; and canereeds, probably the remains of ancient torches of the same character with those found in the Mammoth, Short, and Grand Avenue Caves, were also very abundant.

The most important discovery in this cave, however, was made in a small chamber, about three miles from the entrance, first noticed by my guides, Messrs. Cutlip and Lee. On the dry soil of the floor were to be seen the imprints of the sandalled feet of the former race who had inhabited the cave, while a large number of cast off sandals were found, neatly made of finely braided and twisted leaves of rushes.

A number of other articles were collected here, and were as follows: a small bunch of the inner bark of some tree, evidently prepared for use in the manufacture of an article of dress; several small lots of bark not quite so fine as that composing the bunch; a piece of finely woven cloth of bark, over a foot square, showing black stripes across it where it had been dyed, and also specially interesting in exhibiting the care which had been taken in darning, or mending a portion of it; a small piece of finely made

fringe or tassel discovered in one of the places where the earth had been disturbed; several fragments of large gourds; and two perfect flint arrowheads. Human excrements of great age and showing peculiar habits of life were noticed in numbers; and in several places the soil looked as if burials had been made and the bodies afterwards removed. No human bones were discovered, and the only remnants of articles that we noted indicating any kind of food were a few very much decayed shells of river muscles. A piece of shell of a Unio with a hole bored through it was also found. It is needless to add that everything in this interesting collection which it was possible to bring away was secured, though exposure to the outside air is very detrimental to specimens of vegetable substance so long preserved by the peculiar atmosphere of the cave, and it was only by thoroughly soaking the sandals, cloth, etc., in thin glue and mounting them between glass that I have succeeded in preserving them.

The braided sandals and woven cloth, together with the large gourds which were probably cultivated, and the absence of the bones of any animals used for food, are perhaps indications of an agricultural people dependent on their fields, rather than of a hunting nomadic race. In connection with these cave explorations I may add that I had the opportunity of obtaining the true history of the so-called "American Mummy" which was said to have been found in the Mammoth Cave about the year 1813, and about which so much was written soon after that time. The body was found in Short Cave, about eight miles from the Mammoth Cave, and I examined the spot from which it was taken. Since my return I have examined this most important relic, which is now in the collection of the American Antiquarian Society in Worcester.[1] A careful comparison of the fabrics and articles found in Short Cave with those collected in Salt Cave conclusively proves their identity, and thus throws some light upon the race that made use of the caves for burial places, and gives us the means for the association of the osteological character of the race as determined from this body with articles found in Salt Cave; while from several peculiar conditions of the burial in Short Cave, hints bearing on the great antiquity of the race are given.

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[1] For a detailed account of the cave burials and a more extended presentation of the present paper, see Proceedings of the Boston Society of Natural History, Vol. xvii, p. 314.

A large group of mounds was visited at Pageville, Munroe County, Kentucky. This group consisted of two mounds of about one hundred feet in diameter, and from twelve to fifteen feet high, and a number of smaller mounds about fifty feet in diameter and from three to five feet high. The group lies between Barren River and Peter's Creek, on the homestead of Gen. Joseph H. Lewis, who accompanied me to the spot. A large number of stone implements, undoubtedly made by the moundbuilders, have been found about these mounds, which are now mostly covered by corn-fields. I collected fragments of pottery on the surface. One of the small mounds was opened, but it only showed that a long continued fire had been kept on its top, burning the clay to the depth of several inches. A hole was then dug to the bottom, in the centre of one of the large mounds, yet nothing that could be considered as an undoubted relic of the moundbuilders was found. About three feet from the surface a human skeleton was taken out, though it was probably an intrusive burial by a later race than the one making the mound.

About one-eighth of a mile to the south of these mounds, on the brow of a hill, were found a number of graves of a peculiar character. Many of these graves have been ploughed over, and the human bones from them whiten the field for half an acre in extent. Two of the graves, however, had not been disturbed, at least below the surface, as their walls had been made of slabs of limestone of such size as to prevent the plough from passing over the spot. These graves were nearly circular, between four and five feet in diameter and about three deep. One was carefully opened and its contents taken out. These consisted of portions of fifteen human skeletons and a fragment of pottery. The bones and teeth showed that the bodies buried were those of persons of various ages, from three children, who had not lost their first set of teeth, to one person of old age. The grave had been formed by digging a hole nearly circular and about three feet in depth. Slabs of limestone, about three feet long and from one foot to two feet wide, brought from some distance, had then been placed on end around the hole, and the bottom had been carefully covered with thin shale brought from the creek a quarter of a mile away. The bodies of the adults had evidently been arranged in a sitting posture against the upright slabs and all at one time. Only fragments of the skeletons of the three children were found and the

position in which they had been buried could not be determined. The earth had been thrown over all and a few small flat stones placed above. The fragment of pottery found was near the surface and may indicate that vessels, and perhaps other articles, had been placed on the surface over the grave, and not buried with the bodies, as is more commonly the case.

This class of graves is unlike anything heretofore described, so far as I am now aware, and while it is quite different from anything of which we know among the Indian tribes, it is equally distinct from the burial customs of the moundbuilders so far as at present known. The close proximity of the group of mounds, the extreme care and labor with which the graves had been made, their large number at this place (nearly thirty could be traced, and a very large number must have been entirely destroyed by cultivation of the land over them), and the fact that a number of bodies of various ages were enclosed at the same time in one grave, give occasion for much speculation.

Seven of the crania from this grave were obtained in such condition as to permit of their comparatively perfect restoration, and all the bones found in the grave were brought home, though they were in the last stages of decay, and it was necessary to saturate all with glue in order to preserve them in their present condition.

The several crania obtained from this grave vary somewhat in shape, yet they are, in general, remarkable for their shortness and great parietal width. They all show an occipital flattening which in one skull is very marked. A study of these crania has not been made, but while they resemble the short and high skulls of the moundbuilders, they seem to have some peculiarities not noticed in the few mound skulls I have examined. The long bones of the skeletons indicate a race of ordinary height, though the massiveness of the bones is, perhaps, above the average. The tibiæ are all decidedly flattened, and the femora are, perhaps, slightly more curved than is usual. But on all these points further study is necessary.

REVIEWS AND BOOK NOTICES.

CHEMICAL AND GEOLOGICAL ESSAYS.[1]—The manifest tendency of modern scientific researches and investigations is toward a unification of the sciences, and the volume forming the subject of this notice is a decided step in that direction. We have many and excellent text-books of geology as studied from the standpoints of physics and biology; but, with the exception of Bischof's treatise on chemical geology, which appeared nearly a generation ago, this is the nearest approach to a complete exposition of the intimate relations and interdependence of geology and chemistry which we have seen.

The work comprises twenty of the author's chief scientific memoirs, which have been published at different times during the past twenty-five years. They treat of questions in chemistry, and chemical and dynamical geology, and, to quote from the preface, "cover nearly all the more important points in chemical geology." The author says further that his researches and conclusions as developed in these memoirs "have been connected with the hypothesis of a cooling globe and with certain views of geological dynamics, making together a complete scheme of chemical and physical geology, the outlines of which will be found embodied in Essays I to XIII." Essays XIV and XV are chiefly historical, while the five brief papers which conclude the volume are devoted to the discussion of questions in theoretical chemistry and mineralogy.

In addition to the development of his own ideas, Dr. Hunt has in general given us the results achieved by his co-laborers, so that the work is in truth a fair representation of the present state of the science. Several of the more recently developed of our author's views, as those concerning the use of lithologic data as a basis for chronologic distinctions, and his theory of cycles in sedimentation, have not been generally adopted. The chemical and mineralogical data forming the basis of these hypotheses, however, may be accepted without question, and thus every reader is enabled to form an intelligent judgment concerning the truth of these hypotheses.

Essay XV on the "History of the names Cambrian and Silurian

[1] Chemical and Geological Essays, by Thomas Sterry Hunt, LL.D. 12mo. pp. 489. Boston, 1874. J. R. Osgood & Co.

in Geology," is a very valuable contribution to the history of the science; and its value will increase with time. It throws a flood of light on points of great perplexity for the student; and Dr. Hunt has in writing it, done the science a real service. It is the first complete recognition of the claims of Sedgwick, from the pen of one well qualified to write the history of that painful controversy, and it is to be hoped that the time is not very remote when geologists will generally refuse to recognize the unwarrantable usurpations of Murchison.

Some little repetition has arisen from printing the essays in their original forms, but this could not be avoided, since the author wished to preserve a certain historic value which attaches to the papers, and which would have been lost by a change of forms and dates.

A copious index and table of contents add much to the usefulness of the work.—W. O. C.

CHECK LIST OF NORTH AMERICAN FERNS.[1]—This is a very neatly gotten up 8vo pamphlet, printed on excellent paper on one side of the sheet so as to admit of its being cut for herbarium labels. The specimens are numbered with the same numerals, and the nomenclature substantially agrees with that of Horace Mann's catalogue. I submit a few criticisms on Mr. Robinson's work. "3677[a] Notholæna Newberryi, Eaton, n. sp." The letter following a duplicate should be *b*, the letter *a* being commonly understood as applicable to the first occurrence of a number or name. "D. C. Eaton is given as the authority to other species, the inference being that there are two Eatons, both fern authors, whereas there is but one, the well known New Haven Professor. All herbarium labels and catalogues also for that matter, should have the reference as well as the author. If the original work be not accessible to the compiler then let the reference be to the work from which he quotes. Such a course clears up doubts, prevents blunders, and would here have been particularly useful in the cases of Prof. Eaton's new species. No European author quotes "3763 *Woodsia obtusa* Torrey" (always Hooker), for the reason that his catalogue, published in 1840, is unknown there, and is never quoted in American floras. If Mr. Robinson had referred to the *Synopsis*

[1] Check List of the Ferns of North America north of Mexico; by John Robinson.—Naturalists' Agency, 1873. 8vo. pp.

Filicum he would not have written "3780 *Botrychium virginicum* Swartz, that author and his predecessor Linné. having written *virginianum*. It is difficult to understand upon what principle author's names have been attached to varieties. "*Aspidium aculeatum* Var., Braunii, Koch" may be correct so far as it goes, as correct as if Mr. Robinson had attached Eaton's, A. Wood's, or his own name as the authority, but a reference to Koch's flora would have shown that that author simply quoted Döll who reduced Spinner's *A. Braunii* to a variety of *A. aculeatum*. So also of "*Aspidium spinulosum* Var., *dilatatum* Gray," the fact (if I may use the word in this sense) was published by Roth in 1797, and the name by Hornemann in 1827. In two other cases Mr. Robinson has gone to the opposite and more misleading extreme, "*Aspidium cristatum* Var., *Floridanum* Hooker," and "*Aspidium spinulosum* Var., *intermedium* Willdenow." These authors described the plants as good species; Professor Eaton reduced them to varieties, and should have been quoted as the authority in accordance with the "laws of botanical nomenclature" adopted by Mr. Robinson.

3745c. Var. *Boottii* is the correct orthography, the plant having been named by Prof. Tuckerman after the late Mr. William Boott. The arrangement of *B. Ternatum* is not Swartz's, and scarcely Milde's. The latter author combined three Swartzian species *rutaceum* Svensk. Bot. t. 372, fig. 2), *lunarioides* and *ternatum* under Thunberg's oldest name thus—

"*Botrychium ternatum* (Thunb.)" "Milde Monog. Botrych. p. 146 in Z. V. B."

> "*A. Europœum*" (Rabenhorst, No. 80). I have numerous American species of this variety, the *B. rutæfolium* A. Br.
>
> "*B. Australasiaticum*" (Kunze t. 155; Hook. Fl. Tasman. t. 169). This is the true ternatum and is not N. American so far as I have seen.
>
> "*C. Americanum*" "a. lunarioides (Michx. sp.)" b. obliquum (Menhl. sp.)" "g. dessectum (Menhl. sp.)"

Bernhardi's so-called genus Allosorus is here dropped in favor of Cryptogramme; Prof. Eaton would have done well to have sent Cystopteris into limbo with it. Where space abounds author's names need scarcely be contracted.

We trust Mr. Robinson may find it necessary soon to issue a second edition.—D. A. WATT.

BOTANY.

THE LAW OF EMBRYONIC DEVELOPMENT IN ANIMALS AND PLANTS. —An article upon this subject in the AMERICAN NATURALIST for May contains a hasty generalization, based upon pure assumption, or upon insufficient data, and supported only by a false analogy. It opens with the startling proposition that "it is a well known law in the animal kingdom, that the young or embryonic state of the higher orders of animals resemble (*sic*) the full-grown animals of the lower orders." If such a law had ever been discovered to exist, the tadpole and the caterpillar, which are cited in proof, would certainly be good illustrations of it. But this statement is so far from being "a well known law," or "one of the causes of the recent rapid progress in the study of the animal kingdom," that no eminent living naturalist or biologist recognizes the existence of such a law; or at least no one of them gives a hint of it in his writings.

Agassiz claimed that ancient animals resembled the embryos of recent animals of the same class, and that the geological succession of extinct forms is parallel with the embryological development of existing forms. But if this principle be true, it is far from meeting the requirements of the "law" of this article.

The writer of it may have had in his mind a vague idea of the law of Von Baer, which *is* well known, and which *has* enabled naturalists "to correct their systems of classification," viz.: "That, in its earliest stages, every organism has the greatest number of characters in common with all other organisms, *in their earliest stages*." Or, to put it in language parallel to that of the "law" of this article, false syntax excepted; the embryonic state of the higher orders of animals resembles *the embryonic* (not the full grown) *state* of the lower orders. The germ of a human being differs in no visible respect from the germ of every animal and plant: it never resembles any full grown animal or plant. It successively looses its resemblance to vegetable embryos, then to all embryos but those of Vertebrates, then to all but those of Mammals. Finally it resembles only the embryos of its own order, Primates; and at birth the infant is like the infants of all human races.[1] But never at any period of its successive differentiations

[1] See Spencer's Biology, Vol. I.

does it resemble the *adult form* of fish, reptile, bird, beast, or monkey.

The principle stated is not a law of the animal kingdom. If it be a law at all, it is a newly discovered one, and applies only to the vegetable kingdom.

The proposition to be established then is, that the young or embryonic state of the higher orders of plants resembles the full grown plants of the lower orders. The writer finds his first proof in a comparison of the fovillæ of a pollen grain with full grown Desmidiæ. The points of resemblance are these: both are minute; each consists of a single cell; and both have an apparently aimless motion. Surely, these resemblances are not numerous or striking enough to found a law upon; and if they were, they have not the remotest bearing upon the supposed law. Admitting that the fovillæ "may be regarded as one of the first steps towards the reproduction of plants of the highest type," yet they are not in any sense a *young or embryonic form* of a plant. The fovillæ constitute the male element, and are homologous, not to the *embryo*, but to the *spermatozoa* of animals. The supposed analogy between a Protococcus and a pollen grain is open to the same criticism. Nor is the correspondence between a full grown Botrydium and a pollen tube of greater value. A pollen tube cannot, in any legitimate sense, be called embryonic. The superficial resemblance of a mould fungus to a stamen, is obvious enough; but in reality no analogy can exist between them. The spores of the mould are embryos, and will develop, under favorable circumstances, into mould again. But pollen grains are not embryos, and never, under any circumstances, grow into what, by any stretch of terms, can be called a new plant. Neither stamens nor pollen constitute a part of the embryo; and no analogy drawn from them can have any bearing upon the laws of embryonic development. If such a law as the writer claims really exist, it must be found by studying the development of the *ovule*, the true homologue of the animal embryo. In view of such facts, all "similar analogies" and all similar "proofs of the unity of design of the Creator" may be easily dispensed with.

The article proposes to extend the domain of a certain supposed law of the animal kingdom, so as to include the vegetable kingdom also. It has been shown, First, that no such law exists in the animal kingdom; Second, that not a single fact cited as prov-

ing it to be a law of the vegetable kingdom has the remotest bearing upon the question. If such hasty conclusions as these, wildly jumped at from no data, are to be allowed under the name of Science, her students will richly deserve all the ridicule and sarcasm which a certain class are so fond of pouring upon them.— CHAS. R. DRYER, *Phelps*, *Ontario County*, *N. Y.*, *May* 12, 1875.

COREOPSIS DISCOIDEA SPONTANEOUS IN CONNECTICUT. — Adjoining our cow-pasture is a piece of woodland of about four acres, with beech, birch, chestnut, oaks, etc., growing on it. It is level but has several depressions which form shallow ponds containing water most of the year. In one of these, about a hundred paces in circuit, grow button-bush,'wild-rose sedges, cotton-grass, sphagnum, grasses, at least three species of Bidens or beggar-ticks and *Coreopsis discoidea.* I gathered flowers of the last when just coming into blossom, supposing it to be the common beggar-ticks, at the same time noticing its slender, delicate habit, so unlike the coarse weed of our fields. But, on examining the young ovaries, I could see no sign of the retrorse bristles on their awns, which the achenia of Bidens should have. I thought this might be owing to their immature state. Moreover, on comparing it with Coreopsis, I found it to agree with *C. discoidea* in everything except the *reflexed* outer involucre which an old edition of Prof. Gray's Botany assigned to it. I sent a bit of it to him and he pronounced it *C. discoidea.*

Just after this, I found, in the same place, a plant, very much like the former ones, which had unmistakably the achenia of *Bidens frondosa*, the ciliated outer involucral leaflets of the same, the flower heads just perceptibly larger than those of the Coreopsis, and the same delicate growth of the latter.

In the last edition of Prof. Gray's manual, he gives as one character of the subsection * * * * "scales of the outer involucre reflexed *or* spreading" without indicating to *which* of the four species the *reflexed* involucre belongs. I did not observe any such in the plants I gathered. The awns did not seem to me "*stout*" and they were merely hispid rather than "upwardly barbed."— CHARLES WRIGHT, *Wethersfield*, *Conn.*

FERTILIZATION OF ALPINE FLOWERS BY BUTTERFLIES.—In the ninth of a series of valuable papers communicated by Hermann Müller, to "Nature," on the fertilization of flowers by insects, he

shows that butterflies effect the cross-fertilization of Alpine orchids. It seems that from twelve to fifteen per cent. of the orchids of the lowlands are fertilized by Lepidoptera, while from sixty to eighty per cent. of Alpine orchids are fertilized by the same kind of insects. This corroborates, he says, his view that the predominant frequency of butterflies in the Alpine region must have influenced the adaptation of Alpine flowers.

Müller has also shown the wonderful modifications brought about in the legs and mouth-parts of bees by their efforts in fertilizing flowers.

ZOOLOGY.

On the Development of the Nervous System in Limulus.[1] — After a good many unsuccessful attempts at discovering the first indications of the nervous system in the embryo of Limulus, I at length, in making fine sections, with the aid of the skill of Prof. T. D. Biscoe, discovered it in a transverse section of an embryo in an early stage of development, corresponding to that figured on plate iv, fig. 10, of my essay on the Development of *Limulus Polyphemus* in the Memoirs of the Boston Society of Natural History. The period at which it was first observable was posterior to the first blastodermic moult, and before the appearance of the rudiments of the limbs. The primitive band now surrounds the yolk, being much thicker on one side of the egg than on the other, the limbs budding out from this disk-like thickened portion which represents the outer or nervous layer of the germ. At the time the nervous cord was observed it was entirely differentiated from the nervous layer proper, and in section and relation to the nervous layer appeared much as in Kowalevsky's figure (33) of the germ of Hydrophilus (Embryologische Studien an Würmen und Arthropoden, 1871).

At a later stage in the embryo, represented by Pl. V, fig. 16 in my Memoir, at a period when the body is divided into a head and abdomen, and the limbs are longer than before, by a series of sections parallel with the under surface of the body, I could make out quite satisfactorily the general form of the main nervous cord. It then forms a broad thick mass, the two cords being united, with small holes between the cords opposite the sutures between the segments and situated between the primitive ganglionic centres.

[1] Read at the November (1874) Meeting of the National Academy of Sciences.

The nervous cord, as in the Acarina, is formed long before the other internal systems of organs; the development of the dorsal vessel some time after succeeding that of the nervous cord, while the alimentary canal is not formed until some time after the larva is hatched.

The next stage observed, and one of exceeding interest, was studied in longitudinal sections of the larval Limulus. If we make a longitudinal section of the young king crab when a little over an inch long, the disposition of the cephalothoracic portion of the cord is exactly as in the full-grown individuals. The nervous ganglia are then united into a continuous nervous collar surrounding the œsophagus, no ganglionic enlargements being observed, the collar in fact consisting entirely of ganglia, the commissures being obsolete; in front of the œsophagus and in the same plane as the œsophageal collar lies the supraœsophageal-ganglion, or so-called brain; not as usual in the normal crustacea, raised above the mouth into the roof of the head. On the contrary, the œsophagus passes behind the brain and through the collar at a right angle to the plane of the œsophageal collar and brain taken collectively. Now a section of the larva before moulting shows a most important and interesting difference as regards the ganglia which supply nerves to the appendages of the cephalothorax. These are entirely separate, the spaces between them, where they are connected by commissures, being as wide as the ganglia themselves are thick. Five ganglia were observed corresponding to five anterior pairs of members. It is probably not until after the first moult at least that the adult form of the nervous cord is attained.

Some interesting questions in the morphology of Limulus arise in connection with this discovery of the original separation of the ganglia of the head, which I will simply touch upon. The brain of Limulus differs remarkably from that of the normal crustacea, *i.e.*, the Decapods, in sending off no antennal nerves, but only two pairs of optic nerves, there being in fact in Limulus no antennæ. In the spiders and scorpion the disposition of the nervous system only resembles that of Limulus in the thoracic and cephalic ganglia being somewhat consolidated, but the brain is situated far above the plane of the thoracic mass, and the commissures are very long, and here also there are no antennal nerves, no antennæ being present, but a pair of nerves are distributed to the mandi-

bles. The general analogy in the form of the anterior portion of the nervous cord to the Arachnidan, by no means proves satisfactorily to my mind that the Limulus and Merostomata generally are Arachnida, as some authors insist, for, besides the remarkable difference in the form and position of the supraœsophageal ganglion above mentioned, there are other differences of much importance, which separate the Merostomata from both the Arachnida on the one hand, and the Crustacea on the other.

It will now be a matter of interest to study the development of the nervous cord in the Arachnida, at the stage where the cephalothoracic ganglia are separate and compare them with the same stage in Limulus.

The result may possibly show that the appendages of the anterior region of Limulus are in fact cephalic appendages or mandibles and maxillæ or maxillipeds, and in part truly thoracic; as in the spiders and scorpions the nerves to the maxillæ and legs are distributed from a common cephalothoracic mass of concentrated ganglia. — A. S. PACKARD, Jr.

THE PINE SNAKE. — As having some relation to the animosity which this reptile is supposed by the old residents of the Pines to bear towards the rattlesnake, I find an important observation which I have made, not mentioned in the article of the January number of the NATURALIST. As there noted, the Pine Snake, when alarmed or enraged, slowly inflates itself with air, thus nearly doubling its normal size along its entire length, except the tail. It then slowly expels the air with its own peculiar sound. While thus blowing in anger, the tail is made to perform a singular part in this manifestation of rage. The horny tip, or four-sided spike, is slightly elevated, and caused to vibrate with such rapidity as to produce a little fan of light, about an inch in length. Were this quadrangular spike a little flattened and constricted at intervals, and raised a little higher when set in vibration, we should have, with its buttons and functions, the true organ of the dreaded rattlesnake (*Crotalus horridus*). The sight of this in motion is certainly suggestive of the tail of a Crotalus in rudiment. If the tradition of the Pine Snake's enmity to the rattlesnake be true, it would not be the first instance of disagreement between relations.

In this connection may be mentioned our reading a slip from a

western paper, in which was stated that one of our large innoxious snakes was killed, which had swallowed a rattlesnake, except the tail, which with its rattles projected from the mouth. The statement lacked the mention of names, thus affording no clue for a proper inquiry into the facts of the case.

The old residents of the Pines say that the Pine Snake will follow a person, but that if you approach the reptile, it will at once turn to escape. This habit, indicating inquisitiveness and timidity, Mrs. Mary Treat informs me that she has herself witnessed, in the woods at May's Landing, N. J.

I have received statements from long residents which make it highly probable that the Pine Snake lays its eggs in the sandy soil, where it is dry, and of course somewhat higher than the swamps and streams. Also, I believe that the skunk (*Mephitis chinga*) has much to do with keeping down the increase of *Pituophis*, it being, in the Pines of New Jersey, somewhat expert in finding, and voracious in devouring the eggs of this snake.

Desirous to know whether the Pine Snake does carry the vindictiveness towards the rattlesnake imputed to it, and any other facts that might help to a knowledge of the life-history of the species, I would be glad to see notes on this subject contributed to the NATURALIST, either directly, or through the present writer.—SAMUEL LOCKWOOD, *Freehold, N. J.*

A LITERARY GEM.—In that comedy of errors which one C. G. Giebel caused to be printed under the title of *Thesaurus Ornithologiæ*—that treasury of blunders—it is hard to select the champion error. But the gem of this precious collection is perhaps at p. 96, where we read:—"LINING, J., extract of a letter with his answers to several queries sent to him concerning his experiments of electricity with a kite (Falco).—*Philos. Transact.* 1755, xlviii, 757."

Shade of Ben. Franklin!—with a kite!!—Falco!!! Why did not the accurate and scholarly Giebel say *Falco longicaudatus*—for the kind of "kites" referred to, as every little boy knows, have several yards of tail! This ornithological item is given under head of "Anatomy and Physiology." We sighed, and mechanically turned the leaves back to look under "B" for *Burton's Anatomy of Melancholy*, but the inconsistent Giebel had overlooked this; perhaps he thought his book sad enough already. We beg

to respectfully suggest the following ornithological titles for his next edition :—

THACKERAY, W. M. Adventures of Timothy Titmarsh (*Parus palustris*).

HUSBAND, A. Letter to his Little Duck (*Anas*) of a Wife (*sponsa*), enquiring whether the Baby is still a Creeper (*Certhia*). [N. B. If Dr. Giebel should be in doubt under which one of his xxxiii headings this title should come, he might put it under "Propagatio" or under "Monographs of Families."]

POLICEMAN, A. On the Jayl-birds (*Garrulus*) and Gutter-snipes (*Scolopax gutturalis*) of the metropolis; or, how to go on a Lark (Alauda).

GIEBEL, C. G. Ornithological evidences of Lunacy (Loon-icy, *Colymbus glacialis*).

THE EUROPEAN CABBAGE BUTTERFLY probably made its appearance in the nèighborhood of Cleaveland, Ohio, during the season of 1873, but its ravages did not attract special attention till the summer of 1874, when many thousands of dollars were lost by the wholesale destruction of cabbages and cauliflowers in this section. We have also received notice of similar devastation among these plants in Western Pennsylvania (1874), probably caused by the larvæ of this same insect pest. Fortunately for the vegetable gardeners, however, the active European parasite of the *Pieris*, is also on hand, and scarcely less than ninety per cent. of last year's cocoons are now found more or less completely filled with individuals of the bronzen ichneumon-fly known as *Pteromalus puparum*, either in the larval or pupa state.—T. B. COMSTOCK.

THE LARK BUNTING.—While with the Yellowstone Expedition of 1873, under Gen. Stanley, I collected some material, amongst which was a nest of the Lark bunting, *Calamospiza bicolor* Bonap.), containing three eggs of the same, with one parasitic egg, which I have every reason to believe was that of the Crow Black bird (*Molothrus pecoris* Swainson), as I am well acquainted with the eggs of this bird, and also, because it was found at the same localities, where the Lark bunting seemed to settle. The nests of the latter were generally found at the head-waters of the various streams running either into the Heart or Big Knife Rivers, in fact so close to the springs that in many places the ground was moist. The nests which I found were generally under or amongst tufts of grass, or other shrubs of a stunted

character. Mr. Allen, who accompanied us, has probably described the nests and eggs, ere this, so I will not go into details. —W. HOFFMAN, M.D.

GEOLOGY AND PALEONTOLOGY.

ON THE ORDER AMBLYPODA. — Prof. Cope recently read a paper on the structure of the feet of Bathmodon, showing that they resembled in many points those of the Elephants but differed in others. He finds five toes on each foot, which are very short and furnished with small transverse hoofs. The bones of the carpus resemble closely those of Toxodontia. In the hind foot the arrangement is like that of the Elephants except that the navicular bone is withdrawn to the outer side so as to bring the cuboid and one cuneiform bone into contact with the astragalus. On the characters thus ascertained he based the definition of a new order of mammals. The *Amblypoda* which presents two sub-orders, the Pantodonta represented by Bathmodon, and the Dinocerata represented by Uintatherium.

ANTHROPOLOGY.

PERFORATION OF THE HUMERUS CONJOINED WITH PLATYCNEMISM. —Associated with that extreme development of platycnemism discovered by the writer, some years ago, in the ancient mounds on the Detroit and Rouge Rivers, Michigan, he has found the perforation of the humerus. Allusion is made to that peculiarity of the arm bone in which is presented a communication of the two fossæ at its lower end. It is difficult to arrive at the exact amount of the percentage to which this prevails in these mounds; though there can be little doubt that at least 50 per cent. of the humeri have this characteristic. This is of interest as being in excess of that from the mounds in other parts of the country, where it is calculated as being only 31 per cent. It is a characteristic which, significantly enough, exists in the ape, pertains to the negro in a large degree, while it is very rarely encountered in any of the white races.

In a letter received last year from Prof. Busk, F. R. S., he attaches importance to the writer's discovery of this conformation of the humerus being a peculiarity of platycnemic man, and states

that he does not think such a coincidence has been noticed elsewhere. At any rate it has not been so absolutely established heretofore.

Transitional states of the characteristic, if they may be so called, are also seen in the Rouge River mound; that is, instances in which the communication between the fossæ is not quite completed, the dividing wall being reduced, in some cases to a very thin partition, almost transparent. Even where the perforation is accomplished, there is a great variation in the size of the aperture. — HENRY GILLMAN, *Detroit, Michigan.*

MICROSCOPY.

ATLAS DER DIATOMACEEN KUNDE.—By Adolf Schmidt, assisted by Gründler, Grunow, Janesch, Weissflog and Witt. Publishing in parts, each with four plates. To be completed in from twenty-five to thirty parts. Three parts of this magnificent work have been received. Each plate contains from fifteen to forty figures. The plates are from photographs of original drawings, reproduced by some one of the processes for copying photographs. It is said that nine thousand drawings have been prepared for the work. Size of the plates, fourteen by nine and one-half inches.

It seems to be the aim of the editors to give every known variation of each species of Diatom. For example, plate seven has forty variations of the type *Navicula Smithii* Breb. = *N. elliptica* W. S. Other genera and species are treated in the same manner. Two plates with eighty-nine figures are devoted entirely to the panduriform Navicula. The editors are the most renowned students of this department of natural history in Germany, and the work will be indispensable to all workers in this country, to whom the writings of the German diatomists have been almost inaccessible, scattered as they are among the German periodicals, while for the bibliomaniac it will supply one of the great books of the age. — C. S.

MEASUREMENT OF MÖLLER'S PROBE PLATTE.[1] — *Mr. A. F. Dod, Secretary of the Memphis Microscopical Society, Memphis, Tennessee. Dear Sir:* I have this day finished the measurement of your probe-platte, No. 586. The first thirteen were measured on the evening of March twenty-ninth, by lamp-light; the rest

[1] Read before the Memphis Microscopical Society, April 15, 1875.

were measured, and the thirteenth was remeasured this morning by sunlight. A heliostat was used to give a steady beam of light, and blue glass to make it monochromatic. The index error of the cobweb micrometer was redetermined for the occasion; three observations gave $\frac{9}{97}$, $\frac{9}{96}$, $\frac{9}{96}$, revolutions respectively. This correction was applied in all the calculations. All measurements were repeated; all the striæ measured were counted at least twice. In the first five diatoms, as is well known, the striæ are not of uniform fineness all over the surface of the frustule; in these, one of the measurements is made at the *coarsest* striation which was noticed on the frustule; and another was made on the *same striæ*, but at the point where they converge nearest to each other. Care was taken not to be deceived by spectral lines. An immersion sixteenth, by Tolles, having a maximum angle of 178 degrees, was used in all the measurements:

1.	Triceratium favus,	6 counted	3.63 in 1-1000 inch.				
2.	" "	5	"	3.76	"	"	"
3.	Pinnularia nobilis,	16	"	13.1	"	"	"
4.	" "	15	"	12.4	"	"	"
5.	Navicula lyra,	23	"	17.1	"	"	"
6.	" "	20	"	15.2	"	"	"
7.	" "	21	"	16.6	"	"	"
8.	" "	32	"	25.1	"	"	"
9.	" "	26	"	23.9	"	"	"
10.	Pinnularia interrupta,	18	"	26.7	"	"	"
11.	" "	17	"	25.1	"	"	"
12.	Stauroneis phoenicenteron,	32	"	34.6	"	"	"
13.	" "	32	"	34.5	"	"	"
14.	Grammatophora marina,	38	"	38.4	"	"	"
15.	" "	27	"	38.4	"	"	"
16.	Pleurosigma balticum,	37	"	33.1	"	"	"
17.	" "	33	"	33.1	"	"	"
18.	Pleurosigma acuminatum,	40	"	46.3	"	"	"
19.	" "	25	"	46.6	"	"	"
20.	Nitschia amphioxys,	34	"	49.2	"	"	"
21.	" "	28	"	49.3	"	"	"
22.	Pleurosigma angulatum,	28	"	46.8	"	"	"
23.	" "	24	"	47.1	"	"	"
24.	Grammatophora oceanica,	39	"	61.5	"	"	"
25.	" "	27	"	61.9	"	"	"
26.	Surirella gemma; transverse striæ,	45	"	53.2	"	"	"
27.	" "	35	"	52.8	"	"	"
28.	" "	35	"	54.6	"	"	"
29.	" "	34	"	53.0	"	"	"
30.	" "	21	"	53 8	"	"	"
31.	" "	21	"	53.8	"	"	"
32.	Nitschia sigmoidea,	37	"	61.9	"	"	"
33.	" "	41	"	62.0	"	"	"
34.	" "	49	"	62 5	"	"	"
35.	Pleurosigma fasciola,	20	"	57.8	"	"	"

36. Pleurosigma fasciola, . . .	17 counted	58.2 in 1-1000 inch.	
37. Surirella gemma; longitudinal striæ,	22 "	66.9 " " "	
38. " "	13 "	67.3 " " "	
39. Cymatipleura elliptica, . . .	34 "	63.0 " " "	
40. " "	38 "	63 1 " " "	
41. Navicula crassinervis, . . .	31 "	86.2 " " "	
42. " "	22 "	86.2 " " "	
43. Nitschia curvula, ...	29 "	90.1 " " "	
44. " "	26 "	89.8 " " "	
45. Amphipleura pellucida, . .	30 "	93.4 " " "	
46. " "	17 "	96.1 " " "	
47. " "	23 "	96.0 " " "	
48. " "	27 "	95.3 " " "	

In case you should at any time require it, I can specify more in detail what part of each frustule was subjected to measurement. I have given all the observations in order that by comparing them, you may see, in the case of the coarse diatoms which are very easy to measure, the amount of variation in coarseness on the same frustule; and, in case of the finer, which more easily admit of some error in measurement, the degree of accuracy shown by the accordance of different observations.

It is not till I shall have measured several copies of Moeller's probe-platte, that it will be proper or worth while to make any detailed comparisons of the results. It may, however, be remarked that the two specimens of *T. favus* differ as much as nineteen or twenty per cent. Two vary from fifteen to twenty per cent; two vary from ten to fifteen per cent; six vary from five to ten per cent; ten vary less than five per cent; as compared with my probe-platte. The average variation between the measurements of the corresponding diatoms of the two plates is six and nine-tenths per cent; the average of all the variations shows your platte to have its frustules five per cent. finer than mine. The samples of *Amphipleura pellucida* on the two plates agree within three and two-tenths per cent.—*Very truly yours*, EDWARD W. MORLEY, *Hudson*, *O.*, *April* 10, 1875.

AMERICAN ASSOCIATION.—A full representation of those interested in the microscope is especially desirable at the Detroit meeting of the A. A. A. S., commencing on the 11th of next August, as it is desired to take steps toward the organization of a Microscopical Society, either as a separate society or club, or as a subsection of the large Association. There is a very general desire for a society of American microscopists, and it is believed that such a society can obtain general attendance from the whole

country only at the time and place of meeting of the A. A. A. S., to say nothing of the other very great advantages of meeting in connection with that prominent organization.

NOTES.

The Boston Daily Advertiser, in a recent criticism on the "Statement of the Theory of Education in the United States of America," a pamphlet issued by the Bureau of Education in Washington, offers the following forcible remarks, which illustrate very fairly how favorably the educational ideas of our best scientific men are received by the intelligent part of the community:

"Another point hinted at by the pamphlet is the excessive regard paid to the text-book. The general system of instruction lays special emphasis on the use of text-books, and the prevalent tendency is toward giving the pupil an initiation into the method of using the printed page in the form of books and periodicals for the purpose of obtaining information from the recorded experience of his fellow-men, but in many schools and systems of schools, equal or greater stress is laid upon the practical method of conducting investigations for the purpose of verification and of original discovery. We presume that the last clause, though rather obscure, points at object lessons, field study and the use of the laboratory, but the words employed elsewhere, "the prevailing custom in American schools is to place a book in the hands of the child when he first enters school, and to begin his instruction with teaching him how to read," sufficiently express the fundamental notion of practical education as it prevails in America. The omission, on the one hand, of a public Kindergarten as initiatory, and the close succession of text-books in every department of study, expose one evil in our system which is not likely to be eradicated by any formal enactment or introduction of new systems, but only by the gradual emancipation of the human mind from its present subjection to the printing-press. The extent to which the present system is carried is appalling when we consider it fairly. The teacher is in danger of being buried under the accumulation of text-books; not only the whole field of experimental science is still largely in bondage to the printed page, but the whole field of scientific observation is in danger of being cultivated through the medium of text-books which do not tend to lead the young student to nature, but offer themselves as a substitute for nature. We look indeed to natural science and natural history as the appointed means for freeing the human mind in this direction. The teacher who learns to instruct his classes by direct observation of nature will begin to apply the same principle in other departments of study. English literature, for example, will be taught less by

means of text-books about the subject than by direct contact with literature itself."

The Bulletin of the U. S. Geological and Geographical Survey of the Territories, F. V. Hayden in charge (No. 4, second series, June 10, 1875), contains "Notes on the Surface Features of the Colorado or Front Range of the Rocky Mts.;" by F. V. Hayden, illustrated with fine panoramic views of the Colorado Mountains. "The Tertiary Physopoda of Colorado," by S. H. Scudder, and "Outlines of a Natural Arrangement of the Falconidæ," by Robert Ridgway, with numerous outline cuts. We have also received a "Preliminary Map of Central Colorado, showing the region surveyed in 1873–4," by Hayden's Geological and Geographical Survey of the Territories.

The "Annual Record of Science and Industry for 1874," edited by Spencer F. Baird, with the assistance of eminent men of science, has recently been published by Harper & Brothers. It is a large 12mo of 665 pages. This annual has met with the approval of scientific as well as general students, and is the most reliable and convenient book of the sort published in the language. Several new features have been introduced, which make the present volume still more useful than its predecessors.

In an article in the "American Journal of Science," for May, "On Dr. Koch's Evidence with regard to the Cotemporaneity of Man and the Mastodon in Missouri," Professor Dana, on a review of the evidence, thinks there is sufficient reason for regarding *Dr. Koch's* evidence *very doubtful*, but that future discoveries will establish man's contemporaneity with the mastodon, for he existed in Europe long before the extinction of the American mastodon.

Sachs' elaborate and comprehensive "Text-book of Botany, Morphological and Physiological, has been translated and annotated by Alfred W. Bennett, assisted by W. T. Thiselton Dyer. both excellent authorities. The work is published in sumptuous style by Messrs. Macmillan. Price $12.50. Received from A. A. Smith & Co., Salem. For sale by Lee & Shepard, Boston.

A valuable, illustrated article on the Potato rot, by Professor W. G. Farlow, appears in the "Bulletin of the Bussey Institution," Part iv.

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ALASKAN MUMMIES.

BY W. H. DALL.

For nearly a hundred years it has been known, through the quaint accounts of the early voyagers, that certain tribes of southern Alaska preserved the bodies of their dead. Up to a very recent period, however, no examples of this practice had reached any ethnological museum, or fallen under the observation of any scientific observer. When the territory was purchased, had it continued as accessible as during 1868, it might have reasonably been expected to attract many investigators in Natural History and Ethnology, whose chief difficulty would have been an *embarras de richesse*. But private interest and public indifference united to seal it up from inspection. Naturalists generally are less easily muzzled than poorly paid political appointees, and hence the obstacles thrown in the way of exploration have been so great that we can hardly wonder that so few have been able to enter this rich and interesting field.

During the last four or five years, the investigations of M. Alphonse Pinart, and of the writer, have spread among the residents of the territory some knowledge of the value attached to the ethnological material which surrounds them, and to this fact we owe the collection and preservation of much that is of interest. Among other things which have come to hand in this manner are the only specimens of Alaskan mummies extant.

The practice of preserving the bodies of the dead was in vogue among the inhabitants of the Aleutian Islands and the Kadiak archipelago at the time of their discovery, and probably had been the custom among them for centuries. We find nothing of it on the mainland. It is curious to trace the customs of the wild tribes in this respect in connection with their external surroundings. In the Chukchee peninsula on the Asiatic side of Bering Strait, there is no soil in many places. The substratum of granitoid rock is broken by the frost into hundreds of angular fragments, which are covered with a thin coating of various mosses, which may be stripped off in great pieces like a blanket. There are no trees and but little driftwood. Burial is impracticable, cremation impossible, and the natives expose their dead on some hillside to the tender mercies of bears, dogs and foxes.

In the Yukon valley at a short distance below the surface the soil is permanently frozen, and excavation without iron tools extremely difficult. But timber abounds, and the bodies of the dead, doubled up to economize space, are placed in wooden coffins which are secured without nails and elevated above the surface of the earth on four posts. To scare away wild beasts poles are frequently erected around the coffin, bearing long strips of fur or cloth which are agitated by the wind.

The poor and friendless may be simply covered with a pile of logs, secured by heavy stones; but in general the method is as above. Various modifications are found in various localities; the coffin on the lower Yukon is sometimes filled in with clay, packed hard; and the Nowikakhat Indians sometimes place their dead erect, surrounded by hewn timbers secured like the staves of a cask.

On the islands the soil is unfrozen and there are no obstacles to digging. But wood is only found on the shores, drifted by the ocean currents, and usually not in large quantities. However there are no wild animals to disturb the remains; the beetling cliffs which are found on every hand, shattered by frequent earthquakes, afford in the talus of broken rock at their bases, abundant and convenient rock-shelters. Here the natural depositories exist, of which the natives have availed themselves. On all these customs, originally prompted by the bare necessities of the case, the slow development of sentiment and feeling (which undoubtedly does take place in savage people, though we may not be able to

trace its growth) has grafted animistic ideas, and semi-religious rites and ceremonies. Thus, the original utilitarianism is more or less completely masked or concealed. It is a singular fact that no people have ever adopted the plan of committing their dead to the sea.

Without attempting, at present, to trace the growth of the custom, I will briefly describe the method adopted by the Kaniag and Alēut branches of the Eskimo stock, in preserving the dead. The details are partly given in the older voyages; and have been confirmed and supplemented by an examination of a large number of the mummies, and the traditions of the present natives.

The body was prepared by making an opening in the pelvic region and removing all the internal organs. The cavity was then filled with dry grass and the body placed in running water. This in a short time removed most of the fatty portions, leaving only the skin and muscular tissues. The knees were then brought up to the chin, and the whole body secured as compactly as possible by cords. The bones of the arms were sometimes broken to facilitate the process of compression. In this posture the remains were dried. This required a good deal of attention, the exuding moisture being carefully wiped off from time to time. When thoroughly dried the cords were removed and the body usually wrapped in a shirt, made of the skins of aquatic birds with the feathers on, and variously trimmed and ornamented with exceedingly fine embroidery. Over this were wrapped pieces of matting made of *Elymus* fibre, carefully prepared. This matting varies from quite coarse to exceedingly fine, the best rivalling the most delicate work of the natives of Fayal. It is, indeed, quite impossible to conceive of finer work done in the material used.

The matting was frequently ornamented with checks and stripes of colored fibre, with small designs at the intersections of the stripes, and with the rosy breast-feathers of the *Leucosticte* sewed into it. Over this sometimes a water proof material, made from the split intestines of the sea lion sewed together, was placed. The inner wrappings vary in number and kind but they are all referrible to one or the other of the above kinds. Outside of these were usually the skins of the sea otter or other fur animals, and the whole was secured in a case of sealskins, coarse matting or similar material secured firmly by cords and so arranged as to be capable of suspension.

The case was sometimes cradle shaped, especially when the body was that of an infant. On these occasions it was often of wood, ornamented as highly as their resources would allow, painted with red, blue or green native pigments, carved, adorned with pendants of carved wood and suspended by braided cords of whale sinew from two wooden hoops, like the arches used in the game of croquet.

The innermost wrapping of infants was usually of the finest fur, and from the invariable condition of the contained remains it is probable that the bodies were encased without undergoing the process previously described. The practice of suspension was undoubtedly due to a desire to avoid the dampness induced by contact with the soil. The bodies of infants thus prepared were often retained in the house, by the fond mother, for a long time. Afterwards they were sometimes suspended in the open air: but adults were as far as I have been able to find out, invariably consigned to caves or rock-shelters.

Among the localities which have been visited personally by the writer, are caves in Unga, one of the Shumagin Islands, and others on the islands of Amaknak and Atka, further west. In all of these the remains of mummies existed; but the effect of falling rock from above, and great age, had in all the caves except that of Unga, destroyed the more perishable portions of the remains, and in the latter place only fragments remained.

Many stories, however, came to hand in relation to a cave on the "Islands of the Four Mountains" west of Unalashka, where a large number of perfectly preserved specimens were said to exist, in relation to which the following legend was current among the natives.

Many years ago[1] there lived on the island of Kagámil (one of the Four Mountains) a celebrated chief named Kat-hay-a-kut-chak, small of stature but much feared and respected by the adjacent natives for his courage and success in hunting. He had a son whom he fondly loved, and who was about fifteen years old. For this son he made a bidarka (or skin-boat) highly ornamented and of small size. When it was finished, the boy entreated his father for permission to try it, and after much coaxing was permitted to do so, on condition that he did not go far from the shore. After

[1] The date is fixed as being the fall before the spring in which the first Russians made their appearance at these islands, about 1760.

seeing the boat safely launched the father sat on the hillside watching its progress. The boy became interested in the pursuit of a diving bird at which he threw his dart and which receding from the shore carried the boy away in pursuit, forgetful of his promise.

His father shouted to him but the boy was too far away to hear, and presently it becoming dusk, he could no longer see him and the chief returned to his dwelling.

The boy did not become conscious of the distance he had paddled until out of sight of his own island, and in the darkness he made for the nearest shore.

In those days an Alĕut marrying into another family was accustomed to leave his wife with her people, at least for a certain time; and a native of another island who had married a daughter of the chief was on his way to visit his wife when he saw a little canoe in front of him and recognized his little brother-in-law. The boy did not however recognize the native, and supposing himself pursued paddled away as fast as he could. The brother-in-law tried to frighten him by throwing darts at his canoe, and threw one so carelessly that it hit the boy's paddle and his canoe overturned. The brother-in-law made all speed to catch up with him and attempted to right the boat; but he could not do it, the boy, as is the custom, being tied into the aperture in the top; until, when he did succeed, he found that the boy was dead. His grief may be imagined, and at first he thought of abandoning the canoe where it was, but on reflection he took it to the landing at Kagámil and securing it in the kelp, that it might not float away, he returned to his own island without having seen his wife.

In the morning the chief's servants brought it in, and, to his great sorrow, Kat-hay-a-kut-chak recognized his beloved son.

He caused the body to be prepared for burial, and when the preparation was complete he sent for all the people of the Four Mountain Islands to unite in the ceremonies of depositing the body in the place where the Alĕuts were used to put their dead. The people collected, and together with the chief and his family formed in procession, with songs of lamentation, beating the native tambourines on the way to the burying place. It was autumn and some snow was on the ground which the warm sun had partially melted. On the road lay a large flat stone. The sister of the boy, who was great with child, having her eyes cov-

ered, did not see the stone, slipped, and fell, injuring herself severely, and bringing on premature delivery, which caused her death with that of the infant, on the spot. Now the poor old chief had three to bury instead of one. So he ordered the procession to return to the village, bearing the dead with them.

He then had a cave near his house, which had been used as a place for storage, cleaned out, and after due preparation, the bodies were deposited in this cave, and with them many sea-otter skins, implements, weapons, and all the personal effects of the dead. He then distributed presents and food to the people, saying that he intended to make of this cave, a mausoleum for his family; and that when he himself should die it was his desire to be placed there, with his children. He then told them to eat and drink as much as they desired, but as for himself he should fast and weep for his children. His wishes were carried out, and he was placed in the cave after his death, and since that time the Four Mountain Islands have been abandoned as a place of residence by the natives and only occupied by casual parties of hunters.

The writer attempted in 1873 to reach this locality, but bad weather prevented anchoring; as the shores are mostly precipitous, and there are no harbors. In the summer of 1874, however, the captain of a trading vessel sent there to take off a party of hunters, was guided by some of them to the cave, and succeeded in removing all the perfect mummies and such implements and other ethnological material as could be found. Through the liberality of the Alaska Com. Co. these remains have been received by the National Museum and a careful and detailed account of them has been prepared.

Most of the mummies were wrapped up in skins or matting as previously described, but a few were encased in frames covered with sealskin or fine matting, and still retaining the sinew grummets by which they were suspended. These cases were five-sided, the two lateral ends subtriangular; the back, bottom and sloping top, rectangular, like a buggy top turned upside down.

With them were found some wooden dishes, a few small ivory carvings and toys, a number of other implements, but no weapons except a few lance or dart heads of stone. Two or three women's work bags with their accumulated scraps of embroidery, sinew, tools and raw materials were among the collection.

While space will not suffice here to describe this material in

detail, it may be mentioned that it contained thirteen complete mummies, from infants to adults, two of which were retained in California; and two detached skulls.

None of the material showed any signs of civilized influences, all was of indigenous production, either native to the islands, or derived from inter-native traffic or drift wood. The latter comprised a few pieces of pine resin and bark, birch bark, and fragments of reindeer skin from Aliaska Peninsula.

It will thus be seen that this is one of the most important additions to our knowledge of the prehistoric condition of these people. So far as the specimens differed from those in use in more modern times they resembled more nearly the implements in use among the Eskimo of the mainland. The remains are all those of true aboriginal Alĕuts.

The Kaniagmut Eskimo, inhabiting the peninsula of Aliaska, the Kadiak archipelago and the islands south of the peninsula, added, to the practice of mummifying the dead, the custom of preparing the remains in some cases in natural attitudes, dressing them in elaborately ornamented clothing sometimes with wooden armor, and carved masks. They were represented, women as serving or nursing children; hunters in the chase, seated in canoes and transfixing wooden effigies of the animals they were wont to pursue; old men beating the tambourine, their recognized employment at all the native festivals. During the mystic dances, formerly practised before a stuffed image, the dancers wore a wooden mask which had no eye-holes, but was so arranged that they could only see the ground at their feet. At a certain moment they thought that a spirit, whom it was death or disaster to look upon, descended into the idol. Hence the protection of the mask. A similar idea led them to protect the dead man, gone to the haunts of spirits, from the sight of the supernatural visitor. After their dances were over the temporary idol was destroyed.

We found many relics of this practice in the Unga Caves.

In Kadiak still another custom was in vogue. Those natives who hunted the whale formed a peculiar caste by themselves. Although highly respected for their prowess and the important contributions they made to the food of the community, they were considered during the hunting season as unclean. The profession descended in families and the bodies of successful hunters were preserved with religious care by their successors. These mum-

mies were hidden away in caves only known to the possessors. A certain luck was supposed to attend the possession of bodies of successful hunters. Hence one whaler, if he could, would steal the mummies belonging to another, and secrete them in his own cave, in order to obtain success in his profession.

While M. Pinart was in Kadiak, he heard of the existence of one of these mummies but was unable to discover the locality. Afterwards Mr. Sheeran, the U. S. Deputy Collector of the port of Kadiak, through a peculiar superstition of the christianized(?) natives, was able to discover and secure it. It appears that though nominally all members of the Greek Church they still have great faith in the superstitions of their ancestors, and while the whaleman's superstition has passed away, the natives still regarded the mummy as possessing the power of averting the ill nature of evil spirits, and consequently were accustomed to take to it the first berries and oil of the season. This they asserted, the mummy ate, as the dishes were always empty when they returned for them. Thus annually, they furnished the foxes and spermophiles with a feast. By watching, when the spring offering was made, the locality was detected. The mummy was secured by Mr. Sheeran and placed in an outbuilding near his house. During the season the natives came to him and remonstrated at his not feeding the dead man sufficiently; for he had been seen by a native watchman one foggy night, prowling about the town, presumably in search of food.

This mummy was only covered with a tattered gut-shirt or kamlayka, was in a squatting posture, and held in his hand a stoneheaded lance, on the point of which was transfixed a rude figure cut out of sealskin, supposed by the natives to represent the evil spirits which he held in check. It was that of a middle aged man with hair and tissues in good preservation.

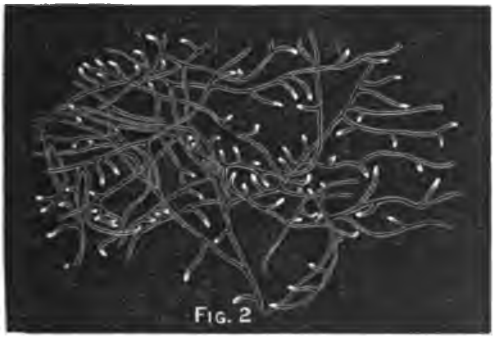
BIOGRAPHIES OF SOME WORMS.

BY A. S. PACKARD, JR.

VI. THE POLYZOA.

The Polyzoa or moss animals derive their common name from their resemblance to mosses. For example, the fresh water *Frederi-*

Fig. 185.



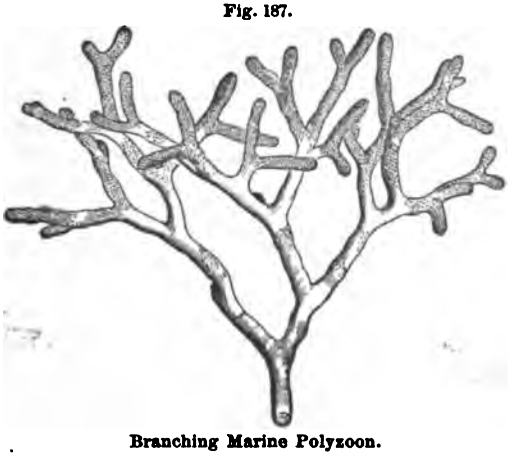
Fresh water Polyzoon.

Fig. 186.

Sea mat.

cella Walcottii (Fig. 185, after Hyatt) would easily be mistaken for moss growing on a submerged stick. The marine species have small-

Fig. 187.



Branching Marine Polyzoon.

er cells and form mat-like encrustations, as in Membranipora (Fig. 186, cells enlarged); or as in *Myriozoum subgracile* (Fig. 187),

they form a coral-like branching mass. On magnifying these cells when the animal is alive and extended from its cell, each polypide, as it is called, appears with its crown of tentacles somewhat like a Sabellid worm. This crown of tentacles surrounds the mouth, which leads by an œsophagus into the throat and a stomach, the latter bent so that the intestine beyond ends very near the mouth; the polypide is thus bent on itself within the cell (cystid) and its body is drawn in and out by muscles. Attached to the end of the fold of the stomach is a cord (funiculus) holding the ovary in place, which extends back to the end of the cystid, as we may call the cell.

Allman regards the polypide and cystid as separate individuals. Now in confirmation of this view we have the singular genus Loxosoma, which is like the polypide of an ordinary Polyzoan, but does not live in a cell. On the other hand, we know of no cystids which are without a polypide (Nitsche).

The affinities of the Polyzoa to the worms are quite decided. In the Phoronis worm, which is allied to Sipunculus, we have the alimentary canal flexed, and the anus situated near the mouth. The Polyzoa have but a single pair of nerve ganglia, and in some cases a tubular heart. The fresh water species are the higher, and are called Phylactolæmata; the marine species are termed Gymnolæmata. All the Polyzoa are hermaphrodite, the ovaries and male glands residing in the same cystid.

Development of the Polyzoa.—Remembering that the cystids stand in the same relation to the polypides as the hydroids to the medusæ, as Nitsche insists, we may regard the polypides as secondary individuals, produced by budding from the cystids. The large masses of cells forming the moss animal, which is thus a compound animal, like a coral stock, arises by budding out from a primary cell. The budding process begins in the endocyst, or inner of the double walls of the body of the cystid, according to Nitsche, but according to an earlier Swedish observer, F. A. Smitt, from certain fat bodies floating in the cystid.

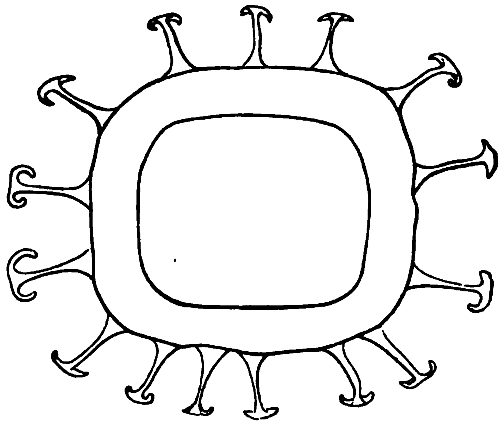
Nitsche has observed the life history of *Flustra membranacea.* He has traced the budding of one cell or zoœcium (representing the cystid individual) from another. During this process the polypide within decays, leaving as a remnant the so-called "brown body," regarded by Smitt as a secretion of the endocyst and germ of a new polypide. After the loss of its first polypide, it can pro-

duce a new one by budding from the endocyst on the side of the stomach. In Loxosoma, young resembling the adult, bud out like polyps.

Nitsche does not regard this budding process as an alternation of generations, but states that in Polyzoa of the family Vesiculariidæ, this may occur, as in them some cystids form the stem, and others (the zoœcia) produce the eggs.

The Polyzoa produce winter and summer eggs, the winter eggs, called *statoblasts*, being protected by a hard shell. Fig. 188, after

Fig. 188.

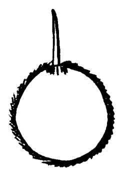


Egg of Pectinatella magnifica.

Hyatt, represents the winter egg of *Pectinatella magnifica*, with spines. These winter eggs crowd the zoœcia, and may be found in them after the polypides have decayed.

Grant first described the ciliated young of the Polyzoa. The Swedish naturalists, Lovén and Smitt, have described the development of the young *Lepralia pallasiana*, which, after passing through a true morula condition, issues from the egg as a flattened ciliated sphere with a single band of larger cilia surrounding one end.

Fig. 189.



Polyzoon larva.

Our figure (189) is copied from Claparède's memoir, and represents the larva of *Bugula avicularia* immediately after escaping from the egg. After swimming about for a while as a spherical ciliated larva, with a bunch of larger cilia (flagellum) at one end, it elongates, looses its cilia and

flagellum, and soon the polypide grows inside, the stomach and tentacles arise, and finally the polypide is formed.

In conclusion, the Polyzoa increase (a) by budding, (b) by normal eggs and winter eggs. In reproducing from eggs the young passes through:

1. Morula state.
2. Trochosphere, much as in certain worms and mollusks, attaining the
3. Adult condition (zoœcium).

LITERATURE.

Smitt. Bidrag till Kännedomen om Hafs-Bryozoernas utveckling.

——— Om Hafs-bryozoernas utveckling och Fettkroppar. (Öfversigt af K. Vet. Akad. Förh. 1865.)

Nitsche. Beiträge zur Anatomie und Entwickelungsgeschichte der phylactolämen Süsswasserbryozoen. (Archiv für Anat. u. Phys. 1868.)

——— Beiträge zur Kenntniss der Bryozoen. (Siebold und Kölliker's Zeitschrift, 1871.)

Claparède. Beiträge zur Anatomie und Entwicklungsgeschichte der Seebryozoen. (Siebold und Kolliker's Zeitschrift, 1870.)

Consult also papers by Grant, Lovén, Huxley, Hyatt and Hincks.

VII. THE BRACHIOPODA.

While the Brachiopods have been regarded by many as closely related to the Polyzoa, there are many features, as insisted on by Prof. Morse, which closely ally them to the Chætopod worms. In his treatise "On the systematic Position of the Brachiopoda,"[1] Morse has given conclusive reasons for removing them from the mollusks and placing them among the worms, and even, in his opinion, among the Chætopods, the highest division of worms. He thus, after giving the anatomical facts in his view sustaining his position, concludes that ancient Chætopod worms culminated in two parallel lines, on the one hand, in the Brachiopods, and on the other, in the fixed and highly cephalized Chætopods.

On the other hand Mr. A. Agassiz, swayed by their relationship to the Polyzoa, remarks that "the close relationship between Brachiopods and Bryozoa cannot be more fully demonstrated than by the beautiful drawings on Pl. v., of Kowalevsky's history of Thecidium. We shall now have at least a rational explanation of the homologies of Brachiopods, and the transition between such types as Pedicellina to Membranipora and other incrusting Bryozoa, is readily explained from the embryology of Thecidium. In

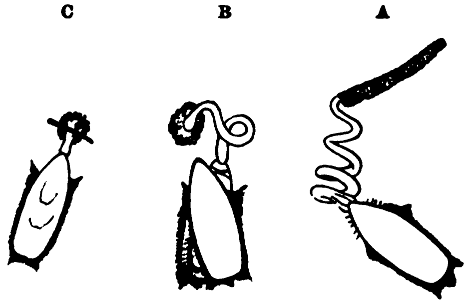
[1] Proceedings of the Boston Society of Natural History, xv, 1873.

fact, all incrusting Bryozoa are only communities of Brachiopods, the valves of which are continuous and soldered together, the flat valve forming a united floor, while the convex valve does not cover the ventral valve, but leaves an opening more or less ornamented for the extension of the lophophore."[1]

In his first paper on the "Earlier Stages of the Terebratulina" Morse had shown the same relationship between the young Brachiopod and the Pedicellina.

The two commonest forms on our coast are the *Terebratulina septentrionalis*, found attached to stems or shells in the seas of New England, while the *Lingula pyrimidata* (Fig. 190, A, with the peduncle perfect, retaining a portion of the sand tube; B, showing the valves in motion, the peduncle broken and a new sand case be-

Fig. 190.



Lingula pyrimidata. After Morse.

ing formed; C, the same with the peduncle broken close to the body, after Morse) is common in sand between tide marks, from North Carolina to Florida. It is usually free, but sometimes attached.

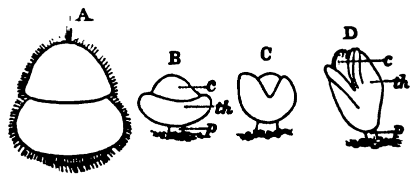
Development of the Brachiopods. The life-history, from the time that it leaves the egg until it attains maturity, of our common lampshell, *Terebratulina septentrionalis*, has been told by Prof. Morse. Before his account appeared our knowledge was extremely fragmentary. Morse believes that in all the Brachiopods the sexes are separate. The eggs (Fig. 192, A), he says, as in the Annélida, when arrived at maturity, escape from the ovaries into the general cavity of the body, and are thence gathered up by the segmental organs, or oviducts, and discharged into the surrounding water. Whether they are fertilized after they leave the

[1] Amer. Journ. Sc. and Arts, Dec., 1874.

parent or before, is not settled. In a few hours after they are discharged the embryos hatch and become clothed with cilia. The earliest stages of the egg of Brachiopods before the larva hatches, were studied by Kowalevsky after the publication of Morse's researches. The Russian zoologist observed in the egg of Thecidium the total segmentation of the yolk (also observed in Terebratulina by Morse), until a blastoderm (ectoderm) is formed around the central segmentation cavity, which contains a few cells. The similar formation of the blastoderm was seen in Argiope, but not the morula stage. After this the ectoderm invaginates and a cavity is formed, opening externally by a primitive mouth. The walls of this cavity now consist of an inner and outer layer (the endoderm and ectoderm). This cavity eventually becomes the digestive cavity of the mature animal. After this the development goes on as previously described by Morse, Kowalevsky's discoveries confirming those of the former observer.

In Terebratulina Morse observed that the oval ciliated germ became segmented, dividing into two and then three rings, with a tuft of long cilia on the anterior end (Fig. 191, A). In this stage the larva is quite active, swimming rappidly about in every direction.

Fig. 191.



Larval stages of Terebratulina.

Soon after, the germ looses its cilia and becomes attached at one end as in Fig. 191, B (*c*, cephalic segment; *th*, thoracic segment; *p*, peduncular or caudal segment). The thoracic ring now increases much in size so as to partially enclose the cephalic segment, as at Fig. 191, C. The form of the Brachiopod is then soon attained, as seen in Fig. 191, D, in which the head (*c*) is seen projecting from the two valves of the shell (*th*), the larger being the ventral plate.

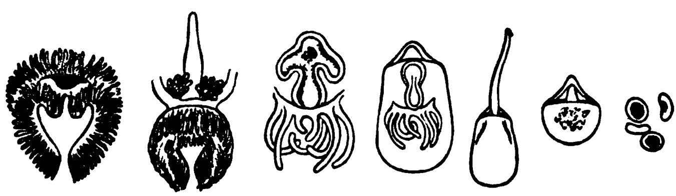
The hinge margin is broad and slightly rounded when looked at from above; a side view however, presents a wide and flattened area, "as is shown in some species of Spirifer, and the embryo for a long time assumes the position that the Spirifer must have assumed." Before the folds have closed over the head, four bundles of bristles appear; these bristles are delicately barbed like those of larval worms. The arms, or cirri, now bud out as two promi-

nences, one on each side of the mouth. Then as the embryo advances in growth the outlines remind one of a Leptæna, an ancient genus of Brachiopods, and in a later stage the form becomes "quite unlike any adult Brachiopod known."

The deciduous bristles are then discarded, and the permanent ones make their appearance, two pairs of arms arise, and now the shell in "its general contour recalls Siphonotreta, placed in the family Discinidæ by Davidson, a genus not occurring above the Silurian." No eye spots could be seen in Terebratulina, though in the young Thecidium they were observed by Lacaze-Duthiers. The young Terebratulina differs from Discina of the same age in being sedentary, while, as observed by Fritz Müller, the latter "swims freely in the water some time after the dorsal and ventral plates, cirri, mouth, œsophagus and stomach have made their appearance." Discina also differs from Terebratulina in having a long and extensible œsophagus and head bearing a crown of eight cirri or tentacles. Regarding the relations of the Brachiopods with the Polyzoa, Morse suggests that there is some likeness between the embryo Brachiopod, and the free embryo of Pedicellina. Fig. 192, B, represents the Terebratulina when in its form it recalls Megerlia or Argiope. C represents a later Lingula-like stage. "It also suggests," says Morse, "in its movements the nervously acting Pedicellina. In this and the several succeeding stages, the mouth points directly backward (forward of authors), or away

Fig. 192.

G F E D C B A



Later stages of Terebratulina.

from the perpendicular end (D) and is surrounded by a few ciliated cirri, which forcibly recall certain Polyzoa. The stomach and intestine form a simple chamber, alternating in their contractions and forcing the particles of food from one portion to the other." Figure 192, E, shows a more advanced stage, in which a fold is seen on each side of the stomach; from the fold is developed the

complicated liver of the adult, as seen in E, which represents the animal about an eighth of an inch long. The arms (lophophore) begin "to assume the horse-shoe-shaped form of Pectinatella and other high Polyzoa. The mouth at this stage begins to turn towards the dorsal valve (ventral of authors), and as the central lobes of the lophophore begin to develop, the lateral arms are deflected as in F. In these stages (G) an epistome[1] is very marked, and it was noticed that the end of the intestine was held to the mantle by an attachment, as in the adult, reminding one of the *funiculus* in the Phylactolæmata" (Polyzoa). Turning now to Kowalevsky's memoir, he shows, according to Mr. A. Agassiz, that the larvæ of Brachiopods are strikingly like those of the Annelides. "The homology between the early embryonic stages of Argiope with well known Annelid larvæ is most remarkable, and the resemblance between some of the stages of Argiope figured by Kowalevsky and the corresponding stages of growth of the so-called Lovén type of development among Annelides is complete. The number of segments is less, but otherwise the main structural features show a closeness of agreement which will make it difficult for conchologists hereafter to claim Brachiopods as their special property. The identity in the ulterior mode of growth between the embryo of Argiope and of Balanoglossus, in the Tornaria stage, is still more striking. We can follow the changes undergone by Argiope while it passes through its Tornaria stage, if we may so call it, and becomes gradually, by a mere modification of the topography of its organs, transformed into a minute pedunculated Brachiopod, differing as far from the Tornaria stage of Argiope as the young Balanoglossus differs from the free swimming Tornaria. In fact, the whole development of Argiope is a remarkable combination of the Lovén and of the Tornaria types of development among worms."

At the close of his first memoir Morse again insists on the close relationship of the Brachiopods and Polyzoa; these views, taken with his later views as to the close relationship of Lingula with the Chætopod worms, show how intimately the Polyzoa and Brachiopods are bound together with the Annelides.

[1] The free lip seemed to perform all the functions pertaining to the epistome in the higher Polyzoa, and we find it on the inner bend of the arms, as in the Polyzoa, though not occupying the same homological position in regard to the flexure of the intestine." Early stages of Terebratulina, p. 34.

It will be seen that neither in the Polyzoa nor Brachiopods are there any true molluscan characters, nothing homologous with the foot, the shell gland or odontophore. The Brachiopods should in our opinion be, perhaps, united with the Polyzoa and form a group lower but sub-parallel with the Annelides. The Brachiopods, from the facts afforded by Morse and others, have neither such a nervous system or respiratory or circulating organs, or an annulated body, as would warrant their union with the Chætopods. He has fully proved that they are a synthetic type, combining the features of different groups of worms, and this fact apparently forbids their being regarded as a group of Chætopods. Looking at the subject from an evolutional point of view, we should be inclined to regard the Brachiopods and Polyzoa as derived from common low vermian ancestors, while the Chætopod worms probably sprang independently from a higher ancestry.

To sum up, the Brachiopods pass through

1. A Morula state.

2. A free swimming, ciliated Gastrula condition, formed by invagination of the ectoderm.

3. Free swimming larval annulate Cephulala stage, combining the characters of the larva of Nareda and of Tornaria the larva of Balanoglossus.

LITERATURE.

Morse. On the Early Stages of *Terebratulina septentrionalis*. (Memoirs Boston Soc. Nat. Hist., 1869.)

——. Embryology of Terebratulina. (Memoirs Bost. Soc. Nat. Hist., 1873.)

Kowalevsky. Investigations upon the Development of Brachiopoda, Moscow, 1874. With papers by Oscar Schmidt, Lacaze-Duthiers, F. Müller and McCrady.

ON ERGOT.[1]

BY WILLIAM CARRUTHERS, F.R.S.

Ergot might supply an interesting text from which to exhibit the worthlessness of speculation as opposed to observation and experiment in dealing with natural science. Replacing, as it does, the seeds of different grasses, and always attaining, when full grown, a greater size than the normal seed, it was at first thought to indicate an extra quantity of life and vigour in the particular seed, which exhausted themselves in the production of the anomalous horned grain. No special properties were associated with these abnormal productions. All along the ergot had been exerting its baneful influence on man and animals without being suspected. Through its agency the inhabitants of whole districts in France had been visited with intermittent attacks of gangrenous diseases; and England, as Professor Henslow has shown in the pages of the 'Journal of the Royal Agricultural Society of England' (vol. ii. pp. 14–19), has records of similar though not so extensive calamities. Yet many years have not elapsed since these and other evils have been traced to their true source,—the consumption of ergotted corn as food.

The remarkable action of ergot on the gravid uterus is well known, and has caused it to be used for many years as a powerful aid in cases of difficult or prolonged parturition. It has been more recently determined that its power of causing muscular contraction extends to all unstriped or involuntary muscular fibre, and it has consequently been applied in treating certain maladies connected with the intestinal canal and the arteries, because these organs, like the gravid uterus, are chiefly composed of this kind of muscular tissue.

The 'Journal of the Royal Agricultural Society of England,' and other periodicals devoted to agricultural subjects, contain frequent narratives of the injuries to stock resulting from the occurrence of ergot in grass crops. Mr. H. Tanner records the loss to one breeder of cattle in Shropshire of 1200*l.* in three years from this cause (vol. xix, p. 40). Recent losses, especially in

[1] From the Journal of the Royal Agricultural Society of England, 1874.

the casting of foals by valuable brood mares, having again drawn attention to the matter, I propose to set down what is known regarding this dangerous production. This is the more necessary, because the views of the latest writers in the 'Journal' on this subject were published before the very important observations of Tulasne were known. This eminent fungologist has fully traced the history and development of ergot, and has finally set at rest the many doubts entertained as to its true nature.

Like all diseases which result from the attacks of fungi, the appearance of ergot is mysterious and more or less inexplicable. Atmospheric conditions, without doubt, greatly influence the development of such plants. Moisture is required for the growth of the minute spores of fungi, which at all times abound in the air: a moist and warm atmosphere invariably brings in all suitable localities a large crop of these minute epiphytic or parasitic fungi. Such conditions, it is well known, greatly favour the production and development of the potato fungus. Ergot also is most abundant in wet seasons; and in the fields where it is seen, it has been found in the greatest abundance in those parts which are low or undrained. Such physical conditions are, however, not present in every instance of the rapid progress of a parasitic fungus. The recent appearance of a blight among garden hollyhocks, and their allies, the wild mallows, is a remarkable exception. This minute fungus (*Puccinia malvacearum*, Mont.) was described by Montagne from Chili, of which country it appears to be a native. It was afterwards noticed in Australia; and a year ago it appeared for the first time in England, in such abundance that it was observed almost everywhere in the south, and in some places not a single Malvaceous plant, wild or cultivated, could be found that had not been attacked by it. It is reported in the same abundance from many districts this year.

It is to be hoped that the growing attention which is being given to these smaller fungi may lead to a better acquaintance with the causes inducing their sudden appearance and rapid development. When these causes are known, one may obtain the power of modifying or controlling, if not of totally preventing, their ravages.

Ergot has been observed on a large number of our native and cultivated grasses as well as on our cereal crops. The grasses that are most subject to its attacks are Rye-grass (*Lolium perenne*, Linn.); the Brome-grasses (*Bromus secalinus*, Linn., *B. mollis*,

Linn., *B. pratensis*, Ehr.); Couch-grass (*Triticum repens*, Linn.); Fox-tail-grass (*Alopecurus pratensis*, Linn.); Timothy-grass (*Phleum pratense*, Linn.); Fescue-grass (*Festuca elatior*, Linn.); Barley-grass (*Hordeum murinum*, Linn.); and Manna-grass (*Glyceria fluitans*, R. Br.). With the view of enabling the reader to recognise this pest, which is made too little account of by agriculturists I have given a number of engravings from remarkably accurate but till now unpublished drawings of its appearance on different plants, made by Francis Bauer, who for several years carefully observed this disease, when he was connected with the Royal Gardens at Kew as botanical draughtsman.

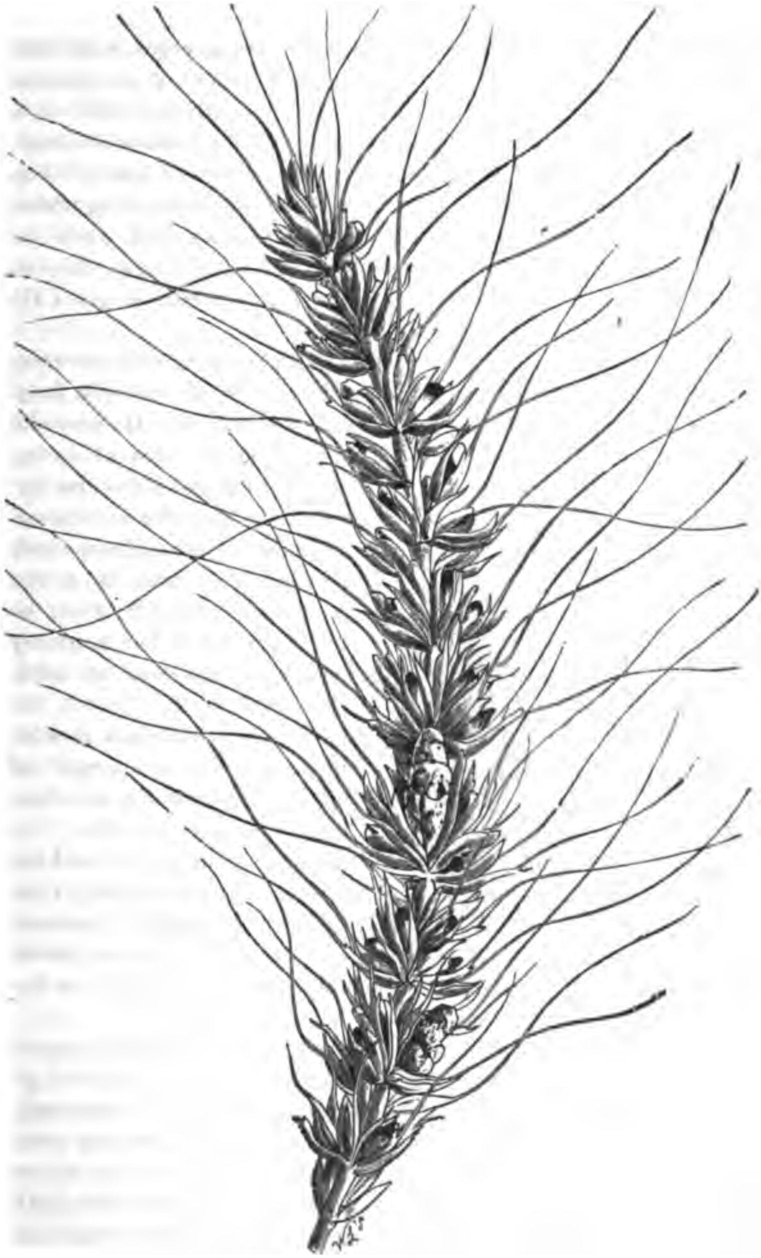
Fig. 193. Fig. 194.

Rye, *Secale cereale*, Linn. Two spikes bearing several Ergots.

As we are most familiar with the appearance of ergot on the cereals, I shall first notice the grain plants affected by it.

That on which it is best known, and from which it is chiefly collected for use in medical practice is Rye (*Secale cereale*, Linn.). In Fig. 193 is shown a spike of rye, with only a single ear affected by a short and thick ergot; but in Fig. 194 several ears are ergotted, and the larger and more slender forms of the majority of the diseased ears exhibit their usual aspect. The great increase in the size of the grain, shown in the drawings, suggested

Fig. 195.



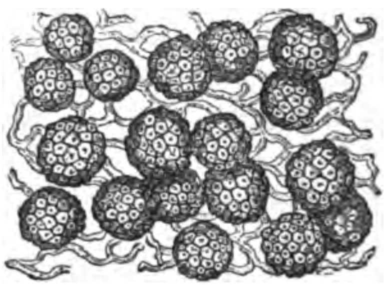
Spike of Spring Wheat affected with Bunt and Ergot. (453)

to Bauhin the name (*Secale luxurians*) he gave to ergot, more than 250 years ago in one of the first published notices of the disease.

In barley and wheat ergot is not so frequently met with as in rye; nevertheless, when carefully sought for, it will often be found. It has been observed in all the cultivated varieties of wheat. Fig. 195 (p. 453) represents a remarkable case of diseased spring wheat, observed by Bauer. Two of the ears only are ergotted, while the great majority are affected by another and better known disease, bunt or pepperbrand, due also to a minute parasitic fungus (*Tilletia caries*, Tul.).

Bauer made a series of experiments with the view of discovering the manner in which different diseases due to microscopic fungi might be communicated to wheat and other cereals. He placed a quantity of the powder (spores) of bunt on the seed of spring wheat, which he then sowed. As the wheat ripened it became extensively affected with the bunt disease. In bunt the contents of the grains are generally completely replaced by a uniform black powder; the grain is brittle and easily crushed between the fingers, when it has a greasy feeling and gives off an offensive fetid smell. Under the microscope this black powder is seen to be composed of spherical spores with a reticulated surface (Fig. 196). If a diseased grain is examined before the spores are fully ripe, they will be seen to be attached by short stalks to a fine branched thread or mycelium, which appears to be absorbed as the spores ripen; it can scarcely be detected in the fully ripe bunt.

Fig. 196.



Spores of Bunt showing the threads of Mycelium. Very highly magnified.

Besides the bunt, ergot also appeared in Bauer's small experimental crop of spring wheat, and in the head figured (Fig. 195, p. 453) he observed that the same grain was attacked by both fungi, as was noticed subsequently by Phillipi and others, and has been illustrated and described by Tulasne. A spikelet from the centre of this head is represented double the size of nature in Fig. 197 (p. 455). This consists of three grains, all diseased. That in the centre is the largest, the great size being due to the growth of

the ergot below the grain itself, which is entirely converted into bunt-spores, and is carried on the apex of the growing ergot and surmounted by the withered remains of the style. This is clearly seen in the section of this grain (Fig. 198), in which the dark colour of the bunt-spores at the apex is contrasted with the lighter-coloured internal structure of the ergot below. The lateral grains of the spikelet are about the size of ordinary wheat-grains, only,

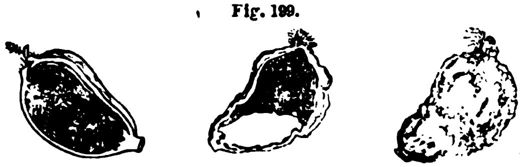
Fig. 197.

Spikelet from the head of Spring Wheat affected with Ergot and Bunt. Twice the natural size.

Fig. 198.

Section of the terminal Grain of the Spikelet.

Fig. 199.



a b c

The lateral grains of the Spikelet. *a* and *b* in section; *c* showing the external appearance. Twice the natural size.

like all bunted grains, they are somewhat shorter and blunter. One of these (Fig. 199, *a*) is entirely converted into bunt-spores, while the other (*b* and *c*), like the central grain, has an ergot established in the lower portion, though still young and very small.

It deserves to be noticed that in both the ergotted grains of this spikelet the early sphacelia state of the ergot is carried up

beyond the ergot itself, and covers the bunted apex of the grains as well.

Maize is subject to the attack of ergot.

The appearance of ergot in rye-grass is well known. Improved husbandry has made this a comparatively rare grass in cultivated fields, where it is of little value as a forage plant, though not so injurious as it has been called; indeed recent experiments make it almost certain that the evils reported and believed to have been produced by the use of darnel have been really caused by the unobserved ergot. The frequency with which rye-grass is attacked has often been noticed. Edward Carroll says he never failed to discover it more or less ergotted in fields allowed to stand for seed, and he adds, what appears to be opposed to general experience, that its extent is in proportion to the wet or dry state of the summer months during its maturation; being rarer when wet, frequent when dry. The probable explanation of this reversing of the experience in England and the Continent is, that it is due to the normal moist atmosphere of Ireland, where Mr. Carroll made his observations, being fitted for the germination of the spores of fungi; while rain would wash the spores off the plants, and a superabundance of water would be unfavourable to their growth.

A head of Timothy-grass (*Phleum pratense*, Linn.) is represented in Fig. 200 (p. 457) with an extraordinary number of ergotted ears. This grass forms a considerable portion of the late meadow crops in many districts.

I have already in the darnel figured the ergot in a weed in cultivated grounds; and in the barley-grass (*Hordeum murinum*, Linn.), Fig. 201 (p. 457), we have it on one of the most common annual grass-weeds of our road-sides and waste places. Although this is a worthless weed, as it is rejected even by the half-starved animals that feed by the road-side, it may be actively injurious to the agriculturist if it is to any extent a nidus for the growth of ergot.

Numerous other illustrations might be given, but our figures of the ergot, as it appears in cereals and in pasture and weed grasses, are sufficient to show the general aspect of this parasitic fungus, and to enable the reader easily to detect it.

No farm or district has any right to hope for exemption from this dangerous pest. It may not have been noticed, or it may have actually been absent for many years, yet it may suddenly,

without any obvious cause, appear in great abundance and prove a cause of serious destruction to the cattle or sheep placed in the field where its presence is not suspected. The late Mr. John Curtis, a keen and learned entomologist, who had an accurate

Fig. 200.

Timothy Grass. *Phleum pratense,* Linn.

Fig. 201.

Barley Grass. *Hordeum murinum*, Linn.

knowledge of the British grasses and a quick eye for natural objects, had for thirty years beaten the ground between Southwold and Kessington, on the coast of Suffolk, for insects, and had never noticed any specimens of ergot till the year 1847, when he found it

on the spikes of *Arundo arenaria*, Linn., in such abundance that he estimated that one-sixth, if not one-fourth, of all the ears of this grass in the district were diseased! ('Gard. Chron.,' 1847, p. 653.)

Fig. 202.

Spikelet of Rye with Ergot. Natural size.

Fig. 203.

Fine Ergot on a foreign species of Lyme Grass, *Elymus giganteus*, Vahl. Natural size.

The different drawings have shown that the ergot bears a certain relation to the seed of the plant in which it occurs, but that in all it attains a larger size than the normal grain, and is especially longer and more horn-like. It occupies the place of the seed, but, unlike most of the parasitic fungi with which agriculturists are acquainted, it sends no roots down into the plant, its whole organisation being confined to the affected ear. The external surface is scaly or somewhat granular, and is generally marked by longitudinal and horizontal cracks, penetrating into and exposing the interior. The colour is black or purple-black, but the interior is white or purplish, and of a dense homogeneous structure (Fig. 204, p. 459), composed of spherical or polygonal cells, so largely charged with an oily fluid[1] as to burn freely when lighted at a candle.[2]

[1] The oil is of a brownish yellow colour, of aromatic flavour and acrid taste; it is viscid, and its specific gravity is ·9249. It consists of 69 per cent. of oleic acid, 23 of palmitic acid, and 8 of glycerine, with traces of acetic and butyric acids and trimethylamin, ammonia and ergotine as colouring matter.—Dr. Herrmann.

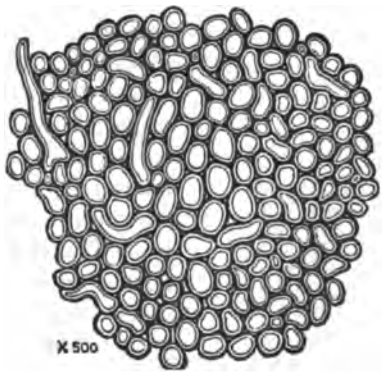
[2] The inorganic constituents of ergot are—

Potash	30·06
Soda	0·65
Lime	1·38
Magnesia	4·87
Alumina	0·58
Oxide of iron	0·86
Oxide of manganese	0·26
Phosphoric acid	45·12
Silica	14·67
Chloride of sodium	1·50
	99·95

Dr. Herrmann in Buchner's 'Repertorium for 1871,' p. 283, and 'Pharmaceutica Journal,' 1873, p. 241.

De Candolle suggested that this anomalous structure had some affinity to the amorphous indurated masses of mycelium which had been united together in a spurious genus to which was given the name *Sclerotium.* The illustrious mycologist Fries separated it from *Sclerotium*, and established a genus for its reception, which he designated *Spermoedium*, although he doubted whether it should be included among the fungi at all, considering it rather as only a morbid condition of the seeds of grasses.

Fig. 204.



Microscopic structure of Ergot, magnified 500 diameters.

The true nature of ergot was at length determined by observations first made on its early history and development on the diseased plants, and then by experiments on the ergot itself, with the view of determining its ultimate product. In both directions the most satisfactory results have been arrived at, and we now know the complete history of the plant.

In its earliest condition this parasitic fungus escapes notice, being composed of a large number of very small elongated cells borne in a colourless liquid. In about three days after the plant is attacked the ergot becomes visible, appearing as a yellowish viscous substance resting on the outer coating of the as yet undeveloped attacked grain (Fig. 205, p. 460). It exudes from between the glumes and more or less completely covers the whole seed. It has a taste like honey and an odour like that of grated bones. The ears naturally attacked do not belong to less vigorous or healthy plants than those that escape.

Once established, the fungus rapidly developes, carrying upwards the aborted remains of the seed, crowned with the withered styles, and forming below the homogeneous sclerotioid mass, which becomes the true ergot. The state of the development of the ergot had been observed early in the century by Bauer, though none of his figures were published till 1841. He had noticed its relation to the outer covering of the seed, and had supposed it to

be an altered condition of that structure ('Linn. Trans.,' vol. xviii, p. 475).

Léveillé, in 1826, noticed that the ergot commenced with this soft covering, and considering it to be a distinct fungus, parasitic on the ergot, he proposed for it the name of *Sphacelia*. John Smith and Quekett, in 1841, published descriptions of the structure of this sphacelia condition, as far as they were able to observe it. They thought it was an amorphous mass of small spherical cells, with a number of larger doubly-nucleated oblong cells scattered among them. It was supposed to be the immediate cause of the ergot, and Quekett gave to it the name of *Ergotætia abortifaciens*, while Berkeley and Broome, believing it to be a true *Oidium*, removed it to that genus under the name *O. abortifaciens*. Bauer's drawings are singularly accurate representations of the general aspect of the disease in its different stages, and while his microscope disclosed to him in 1805 all that Quekett published in 1841, it was not sufficient to exhibit the minute structure as it has been recently described and figured by Tulasne. In Bauer's drawings (Fig. 206, p. 461) the sphacelia is represented as consisting of tortuous and anastomosing ridges or plates, with numerous open cavities in the interior. Tulasne showed that the sphacelia was organically connected with the ergot, and was, indeed, only a condition of it.

Fig. 205.

A Grain of Rye covered with early, or sphacelia, state of Ergot. Twice the natural size.

Bauer detected the elongated nucleated cells of the sphacelia, but, like Quekett, he did not observe their connection with the supporting structures; while the cavities accurately represented by Bauer in the foldings of the sphacelia (Fig. 206) are the free spaces where the nucleated cells or "spores" are produced.

The illustration (Fig. 207, p. 462), copied from Tulasne, shows the relation of the different structures. The dark lower portions of the woodcut is a section through the growing sclerotium or ergot, properly so called. This is composed, as we have already seen, of densely-packed polygonal cells, filled with oil globules. On its outer surface and from its apex are given off elongated

cells, which are the supports (sterigmata) of oblong cells (spermatia or conidia), the most of which are free in the drawing. These cells are the spores of the *Ergotætia* of Quekett, and the *Oidium* of Berkeley and Broome. The oblong cells or "spores,"

Fig. 206.

Ergotted ear of Rye, showing the early sphacelia state at the apex, and the young Ergot at the base. *a*, external appearance; *b*, section. Magnified six times.

when placed in water, freely germinate (Fig. 207, *a*), and they have the power of reproducing the parasite. But we have not here the perfect condition of the plant. Recent observations have shown that many fungi produce at different stages of their history free cells possessed with the power of germination. The sper-

matia-bearing stage has been observed in other fungi besides the ergot.

When the ergot attains its full size the sphacelia disappears, or only the withered and dried up remains of it can be detected at the apex of the ergot.

The further history of the ergot has been determined also by Tulasne. The frequent occurrence of minute sphærias on the ergotted grains of grasses suggested to him that they were probably not accidental productions, as had been supposed, but were

Fig. 207.

Magnified section of an Ergot covered with the Sphacelia; *a*, spermatia germinating in water. (From Tulasne.)

organically connected with the ergot, and represented a further stage of its development. With the view of testing this opinion, he planted a number of ergotted grains, and had the satisfaction to find that a considerable proportion produced sphærias. Those produced by the ergot of rye were the same in form and structure with what were grown from the ergots of most of the other grasses, and believing them all to belong to the same species, he gave to it the name of *Claviceps purpurea* (Fig. 208, p. 463). This perfect plant is a small purplish fungus, with a spherical head, supported on a short firm stem, with a somewhat downy base. The

globose head is rough with small prominences, which are the openings of the cavities or conceptacles in which the spores are produced (Fig. 208, *b* and *c*). One of these conceptacles, highly magnified, is shown in Fig. 209, *a* (p. 464) representing the oval cavity filled with the long slender spore cases (asci) springing from the base of the cavity. The mouth of the conceptacle opening through the conical swelling is obvious; this gives the granular aspect to the head of the fungus. Four of the sacs or asci are represented at *b*, still more magnified. They are seen to be filled

Fig. 208.

a, Ergot of Wheat producing the small Fungus, *Claviceps purpurea*, Tul.; *b*, one of the heads magnified. *c*, section through a head, to show the cavities containing the spores. (From Tulasne.)

with slender needle-shaped bodies, which are the ultimate and perfect reproductive spores of the ergot. A few of these spores are represented still more magnified at *c*.

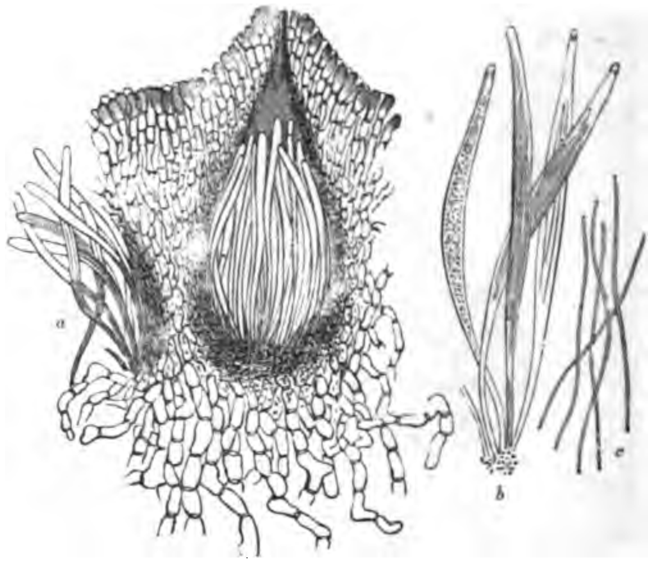
Having traced the history of the ergot, we may now inquire how and at what time the crops get infected, with the view of seeing whether it is possible to discover any means of alleviating, if not of destroying, this injurious parasite.

At two different stages in the life of ergot, bodies are produced which have the power of propagating the disease, namely, the

spores of the perfect fungus developed from the ergot, or the "spores" (spermatia or conidia) of the early sphacelia state of the parasite.

The plant is carried over the winter in the dormant ergot condition. A large proportion of the ergot in a field, when it is fully ripe, falls to the ground during the operations of the harvest, or by the friction of the spikes against each other through the action of the wind. These ergots remain on the ground during the winter without undergoing any change. They are dormant, like the

Fig. 209.



a, magnified section of a conceptacle, showing the slender spore-cases. and the tumid mouth of the cavity; *b*, spore-cases magnified; *c*, single spores. (From Tulasne.)

seeds of plants, until the following spring or summer, when they produce crops of the perfect fungus (*Claviceps purpurea*, Tul.). The spores of the *Claviceps* are ripe about the time that the cereals come into flower, and by the action of wind or rain they obtain access to the flowers.

In 1856 Durieu communicated ergot to rye by placing the spores of the *Claviceps* on its flowers. Roze has since confirmed and extended these observations ('Bulletin Soc. Bot. de France,' 1870).

It is, then, by these minute needle-like spores that the disease is communicated at first to all crops; and the principal effort of

the farmer who desires to free himself from this pest should be to secure clean seed, perfectly free from ergot. The ergot is too frequently overlooked in the barn from its resemblance to the dung of mice; but it is worth special pains in examining the seed to secure immunity from this parasite. Tulasne states as the result of his experiments that if the ergot does not produce the *Claviceps* during the first year after it has fallen to the ground, it loses its vital powers. One might hope to find in this observation of Tulasne the means of coping with the disease; and certainly it is most desirable not to follow an ergotted crop with another crop of cereals. But it must be remembered that the same species of fungus produces an ergot in most of our grasses, and that the spores belonging to the *Claviceps* of these grass ergots will as readily communicate the disease to cereals as those produced by the cereals themselves. We may, therefore, have in ergotted grasses growing in the margins of fields or along hedge-banks the means of maintaining and spreading the disease in cereal crops. No trouble should be spared to collect and destroy the ergots on such grasses. To permit them to fall to the ground is a certain method of securing the appearance of the disease on any cereal or grass crops in the neighbourhood in the following year.

But the disease having once appeared in a field of growing grain, or amongst hay or grass, easily spreads itself in its early sphacelia state. Every one of the "spores" (spermatia) has the power, as we have seen, of germinating, and so spreading the disease. The striking of an ergotted head against a healthy plant will communicate the disease. This has been experimentally tested by Bonarden, and confirmed by Roze. It is not possible, however, to interpose at this stage of the malady with the view of arresting it. The diseased grains are difficult to discover in the field, and it would be hopeless to attempt to pick them out. The disease can only be effectually dealt with while the plant is in its dormant state as an ergot, as already pointed out.

REVIEWS AND BOOK NOTICES.

DR. COUES'S BIRDS OF THE NORTHWEST.[1]—This volume of eight hundred pages forms "No. 3" of the "Miscellaneous Publications" of the United States Geological Survey of the Territories, F. V. Hayden, U. S. Geologist in Charge. As its title indicates, it is intended as a Hand-book of the whole region drained by the Missouri and its tributaries. It thus embraces a large area in the interior of the continent, including the whole of Nebraska, the greater portions of Dakota, Montana, Wyoming, Colorado, Kansas and Missouri, with portions also of Iowa and Minnesota. This region embraces the greater part of the so-called Middle Faunal Province of North America, but overlaps also the eastern edge of the Western Province and the western edge of the Eastern Province. It hence includes the greater part of the birds of the continent, embracing nearly all of those of the Eastern Province as well as those of the Middle Province. Most of this extended region is embraced within the great elevated central plateau of the continent, where the annual rain-fall is low; owing to this fact, the vegetation is meagre and stunted, and the country generally treeless. As the author says, "Trees are in effect restricted to the mountainous tracts, and to a slender, precarious fringe along most of the larger streams." This precarious fringe, however, is sufficient to entice the eastern tree-nesting species far up into the interior of this vast sterile plain, curiously blending the faunas of the Eastern and Middle Provinces by a series of interdigitations.

The topics specially treated in this work, among the most prominent of which is the geographical distribution of the species, receive that thorough attention which is so well known to mark all the work that Dr. Coues undertakes. Their distribution is given not only with definiteness for the special region under consideration, but also for the whole range of each of the species treated. Their areas of residence and range of migration, together with their relative abundance or scarcity, over different

[1] Birds of the Northwest: A Hand-book of the Ornithology of the Region drained by the Missouri River and its Tributaries. By Elliot Coues, Captain and Assistant Surgeon U. S. Army. Washington: Government Printing Office. 1874. 8vo. pp. xi, 791.

parts of their respective habitats, are given with a degree of detail never before attempted for the birds of this country, if ever before for any country. The synonymy is also uniformly worked out with greater detail than ever before, while the number of bibliographical references given for each species far exceeds the number heretofore given in any work on American ornithology. While not only all references of any importance are generally given (we observe here and there a few rather noteworthy omissions) the nature of the special papers cited is usually indicated, and the authorities for the special facts of distribution are stated, thereby adding greatly to the value of the bibliographical portion of the work.

A redescription of the species was deemed unnecessary, since, in view of the several excellent descriptive works that are now so generally accessible, it seemed needless to swell the size of the work by a repetition of such descriptions. The matter of the volume is hence almost entirely new, the biographical portion, as the writer says, being based mainly upon his own personal observations. He has, however, not only made use of numerous manuscript notes given him for his work by several of his fellow ornithologists, but has collected and combined in a most satisfactory manner the recent contributions of other authors, published in detached papers in different and not generally accessible scientific journals. Dr. Coues's aim being to contribute new material for future elaboration, rather than to prepare complete histories of each species described, which, however desirable, was, under the circumstances, wholly impracticable, he has devoted generally but a few lines to the well-known species of Eastern birds, while he has been able to furnish very nearly complete biographies of some of the heretofore slightly known Western species. The volume ends with monographs of several families of the water birds—*Laridæ*, *Colymbidæ* and *Podicipidæ*—to which, as is well-known, Dr. Coues has for a long time given special attention. These are worthy of an extended critical notice, which want of space will not at this time permit.

A thorough and detailed index of more than fifty three-column pages fitly closes the volume, crowning a work that will ever remain a monument to its indefatigable author, and a source of profit and pleasure to future workers in the same field. The amount of drudgery represented in these pages, which sooner or later some one must have done, places ornithologists particulary

under obligations to the author, while his easy-flowing, graceful and sprightly pages of biographical matter, glowing with the enthusiasm of the naturalist, and evincing the inspiration of actual contact in their natural haunts with the objects described, will render his book a pleasing and attractive one to the general reader.

But the author is not alone entitled to our thanks or our congratulations. It must not be forgotten that Dr. Hayden's early explorations in the Upper Missouri region, together with the later collections made under his direction as Geologist in charge of the Geological Survey of the Territories, have furnished both the basis and the occasion for the present report, and that to his wise liberality we are indebted for its publication.—J. A. A.

BOTANY.

Botrychium simplex, with pinnated divisions to the sterile frond.— In 1873, Mr. E. W. Munday sent, from Syracuse, New York, a large specimen of *Botrychium simplex*, having four pairs of broadly wedge-shaped divisions to the sterile part of the frond, these merely incised at the broad terminal margin. From Syracuse, Mrs. Styles M. Rust now sends a very robust specimen, apparently of the same species, but of a different aspect, the divisions of the sterile part of the frond being more approximate, narrowly oblong in shape, and strongly pinnatifid. The texture is that of *B. simplex*, *i.e.*, thick and rather fleshy. This may interest our fern-students and collectors. The variety may take the name of var. *bipinnatifidum*.—A. Gray.

Fucas serratus.— Colonel Pike has personally assured me that this Fucus was abundant at Newburyport when he was there in 1852. Rev. J. Fowler sent me some from Pictou harbor in 1869, and again lately in large quantity, the plant several feet long, and fruiting abundantly. He writes that he collected it Nov. 1, 1874, and that "it seemed abundant on the rocks round the harbor, and had every appearance of being a native."— Daniel C. Eaton.

Menyanthes trifoliata, the *Buck-bean*, has dimorphous flowers, according to the observations of C. A. Wheeler, of Hubbardston, Michigan, who also calls attention to the fact that Kuhn, in Germany (in "Botanische Zeitung," 1867), includes this in a list of dimorphic genera. It had escaped our attention.—A. G.

ZOOLOGY.

Description of a New Wren from Eastern Florida.—*Thryothorus Ludovicianus* (Lath.), var. *Miamensis*, Ridgw. Florida Wren. *Diagnosis.*— Similis *T. ludoviciano*, sed major, robustior, et coloribus saturatioribus. Alæ, 2·75; cauda, 2·60; culmen, ·90; tarsus, ·95; dig. med. (sine ungue), ·60.

Hab. in Florida orientale (Miami River, Jan., 1874, C. J. Maynard). Typus No. 1864, Mus. R. R.

Similar to *T. Ludovicianus* (Lath.), but larger, stouter, and more deeply colored. Above rusty-chestnut, most castaneous on the back, and becoming browner on the forehead. Wings and tail with indistinct, narrow, dusky bars, and rump with concealed white spots; a wide post-ocular stripe of dark rusty on the upper half of the auriculars, running back into the rusty of the nape. Below deep rusty ochraceous, the sides and flanks showing indistinct bars of darker rusty; chin and crissum soiled whitish, the latter banded with dusky black; a continuous superciliary stripe of pale ochraceous, bordered above by a blackish line along each side of the pileum; cheeks grayish soiled white, with faint crescentic bars of dusky. Bill dusky, the superior tomium and lower mandible pale (lilaceous in life?); feet pale horn color. Wing, 2·75; tail, 2·60; culmen, ·90; tarsus, ·95: middle toe (without the claw), ·60.

Habitat.—Miami River, eastern Florida (January 9, 1874; C. J. Maynard). Type No. 1864, Mus. R. R.

Remarks.—In coloration, this strongly-marked form closely resembles *T. Berlandieri* Baird of the lower Rio Grande (see Hist. N. Am. B., I, p. 144, pl. ix, fig. 2), but the size is greatly larger than even the most northern examples of *Ludovicianus* proper, while *Berlandieri* is smaller. It is very remarkable that the southern form of this bird should be so much larger than the northern one, in direct opposition to a recognized law of climatic variation, but we have another case of this same exception to the rule in *Catherpes Mexicanus* (Swains.), and its northern race, var. *conspersus* Ridgw. (see Hist. N. Am. B., I, pp. 138–140, and III, 503); these examples probably justifying the suggestion made by the writer (*op. cit.*, iii, 503), that an exception to the rule of de-

crease in size to the southward, in resident species, may be made in case of families or groups of families which have in temperate latitudes only outlying genera or species, the increase in this case being to the southward, or towards the region in which the family or group is most highly developed!—ROBERT RIDGWAY.

THE FRIGATE BIRD AND WHITE IBIS IN CONNECTICUT.— The occurrence of *Tachypetes aquilus* in Connecticut is not generally known, Long Island being, up to this time, the northernmost locality on record for this bird. A female of this species was killed at Faulkner's Island in this state in the autumn of 1859, and is now in the collection of Capt. Brooks. It was hovering over the island when shot. Late in the afternoon of May 23, I observed near Milford, Conn., a specimen of *Ibis alba*. I recognized the bird as it flew over me, and following it to a small pond where it went down, discovered it perched upon a tree over the water. I carefully examined it with a good glass, at a distance of about one hundred and fifty yards, and by this means was enabled to note every detail of form and color. It was in full plumage, the white being pure, and the naked skin about the head, bright red. After watching it for a few moments I tried to approach it, but before I came within gunshot it flew, uttering a hoarse cackle as it went off.—GEO. BIRD GRINNELL, *New Haven, Connecticnt.*

NEW BIRDS IN KANSAS.—The following additions to the Kansas list have recently been made: *Micropalama himantopus*, near Lawrence, Sept. 9th and 19th, 1874, by W. Osburn; *Calidris arenaria*, same locality, Oct. 7th, 1874, by W. E. Stevens; *Ægiothus linaria*, at Baldwin, fourteen miles from Lawrence, March 13th, 1875, by John Holzapfel, also seen in Western Kansas in November, by Mr. Trippe, as recorded in Dr. Coues' "Birds of the Northwest;" *Dendroeca palmarum*, at Topeka, May 6th, 1875, by E. A. Popenol. To these should be added *Ampelis garrulus*, a specimen of which taken at Fort Riley, by Dr. Hammond, is in the Smithsonian collection. The Kansas List now contains 292 species.— F. H. SNOW, *Lawrence, Kansas.*

NEMATOIDS IN PLANTS.— Greef found (SB. Ges. Marburg, 1872) certain tubercles on the root-fibres of *Dodaxia orientalis* full of Anguillulæ in all stages, from the egg to the mature and preg-

nant state (these had previously been found in similar galls on the root-fibres of *Sedum* and grasses). On Anguillulæ of *Talcaria Rivinii* compare Frauenfeld, Verh., Z.-B., Ges. Wien, xxii, p. 396. — *Zoological Record for* 1872.

GEOLOGY AND PALEONTOLOGY.

The Disintegration of Rocks and its Geological Significance.[1]—This subject the speaker had briefly noticed in a communication to the Association in 1873, on the geology of the Blue Ridge. The change of the rocks in question is a chemical one, which is most obvious in the case of crystalline rocks; the feldspar loses its alkalies and part of its silica, being changed into clay, and the hornblende its lime and magnesia, retaining its iron as peroxide. From this results a softening and decay of the rocks to greater or less depths, so that while the beds still retain their arrangement, and are seen to be traversed by veins of quartz and of metallic ores, they are often so much changed to depths of a hundred feet or more as to be readily removed by the action of water. This phenomenon is well seen in the crystalline rocks of the Blue Ridge, and not less remarkably in those of Brazil, where it has been noticed by many observers, among the latest of which is Professor Hartt. Darwin, who long ago described it, imagined the change to have been effected beneath the sea, but according to the speaker it has been a sub-aërial process, which has been at work during past ages, when the composition of the atmosphere and the climatic conditions differed from those of to-day, and when carbonic acid, aided by warmth and moisture, abounded. He connected it with that slow purification of the atmosphere which, from very early times, has been going on. The alkalies and lime and magnesia, set free in this process, absorbed the atmospheric carbonic acid, and the carbonates carried down to the sea in a dissolved state gave rise to limestones, dolomites, and common salt. Such a process of decay was already active at an early period, and, from facts observed in Missouri by Pumpelly, had affected the iron-bearing feldspar-porphyries at the commencement of palæozoic time. It was, according to the speaker, from the washing down of the thus decomposed crystalline rocks that all the clays and sands which had gone to build up the sediments

[1] Abstract of a paper read before the American Association for the Advancement of Science, at the Hartford Meeting, August, 1874.

of our vast beds of palæozoic and more recent rocks had been either directly or indirectly derived. This had already been pointed out by Lyell for the tertiaries of the southern states. He thought it probable that the process of decay had gone on with decreasing energy to our times, though it is now insignificant in its action, owing to changed atmospheric conditions.

The speaker drew a picture of North America in past geological ages. The frequently taught notion of the growth of our continent southward and outward from a nucleus in the vicinity of the great lakes has no foundation in fact, and the study of the uncrystalline sedimentary formations tells a different story. The great palæozoic basin was to the east and west, as well as the north, surrounded by areas of decaying crystalline rocks. Those of New England, of the Blue Ridge, and of the crystalline area to the east of it are the remains of a great disintegrated and wasted continent, whose ruins have built up the uncrystalline rocks to the westward of it, as well as the sediments along the eastern and southern borders of the United States. Up to a comparatively recent period, the hills of New England, eastern New York and New Jersey, were probably, like those farther southward along the Blue Ridge, deeply covered by the products of their own decay, and from these were derived the clays, as well as the brown iron ores which are found along the base of the Blue Ridge and its northeastern continuation.

It was during the glacial period, which the speaker considered to have been one of submergence and subsequent gradual uplift of northeastern America, at which time it was exposed to the action of local glaciers and to the iceberg-drift of the polar current, that the final removal of this decayed covering from our hills had taken place, while farther southward the mountains beyond the reach of this denuding action still retained to-day their covering of decayed rock. A similar condition of things is to be seen in northwestern Minnesota, where, according to White, the decayed crystallines have escaped denudation. The process of decay in the more massive and granite-like rocks had often been incomplete, and working from natural joints had left unchanged nuclei of hard rock which, when erosion took place, remained as rounded masses or bowlders; a point which has been well brought out by Mr. Burbank from his studies in North Carolina, and throws much light on our northern drift-deposits.

A profound decay had also affected the hard palæozoic limestones, from which the carbonate of lime had been dissolved, leaving a porous, rotten rock behind. This, as Dawson has shown, is well seen in the impure argillaceous Trenton limestone near Montreal, which, in localities protected by trappean dikes from the eroding action which came from the northeast, is found deeply decayed, while elsewhere, near by, its hard surface is worn down and glaciated. Examples of a similar local exemption of the decayed crystalline rocks from erosion are not wanting in New England.[1]

The speaker alluded, in closing, to a process of mechanical disintegration, without chemical change, which in past ages had broken up undecayed crystalline rocks to form breccias and conglomerates. These are seen locally, from the ancient porphyry-conglomerates of the Lake Superior copper-mines to very recent deposits, and a remarkable example is met with in the beds of granitic material, which, in a recemented state, make up parts of the red sandstone of the Connecticut valley. The slow breaking up of many crystalline rocks by the action of frost had been suggested by Dawson as a potent agent in the production of such material, and the speaker conceived that this, in the present state of our knowledge, was the most probable explanation of its origin.—T. Sterry Hunt.

ANTHROPOLOGY.

Artificial Perforation of the Cranium.—I wish to call attention to what seems to me to betoken a singular practice connected with the burial ceremonies of the aboriginal inhabitants of this country, and of which I can find nothing on record in the books, notwithstanding the remarkable nature of the custom, and the indubitable marks which would remain to testify in instances where it had been adhered to. I have reference to the artificial perforation of the top of the head after death.

The circular aperture, evidently made by boring with a rude, probably stone, implement, varies in size, in some instances having

[1] An example of this is seen in Kent in Connecticut, and also in North Adams, Massachusetts, where the tunnel lately made through the Hoosac Mountain shows that the gneiss rock at its western base is completely decomposed to a depth of 200 feet or more; while on the summit of the mountain are seen worn and glaciated surfaces of the same rock in an undecomposed state.

a diameter of one-third, in others one-half of an inch, and flaring at the surface. It is invariably placed in a central position at the top of the skull.

The first instance of its being brought to my knowledge was in the year 1869, when I took from the Great Mound on the River Rouge, Michigan, two fragments of crania, each of which exhibited this perforation. A skull recently presented to the museum of the Detroit Scientific Association by Mr. A. C. Davis, and which was exhumed from a mound on the Sâble River, Lake Huron, Michigan, also has this mark. From ten to fifteen skulls were taken from the same mound, all being similarly perforated, and there being, as I am informed, no other remains interred with them. During last Summer (1874), in some further excavations made in the Great Mound at the River Rouge, among other relics exhumed were eight crania, two of which had this aperture. Of the remaining bones of the bodies pertaining to the two skulls in question, I specially noticed that many were wanting, and that those present were heaped *en masse*, and not in the usual manner of burial, seeming to imply that they were interred subsequently to being denuded of the flesh and the other soft parts of the body.

Besides the foregoing instances of this curious custom which have been brought to my immediate knowledge, I have since been informed of the finding of a skull at Saginaw, Michigan, which presented the peculiarity; but in this case there were three perforations arranged cocoanut fashion.

All enquiry which I have made of learned societies or individuals in regard to this observance has elicited an utter disclaiming of all knowledge on the subject. The two largest collections in Ethnology in this country, the Smithsonian Institution and the Peabody Museum, contain no evidence of it. Prof. Joseph Henry, in replying to my queries, stated that the only information he had procured in relation to perforated skulls was the following from Prof. Mason of Columbian College: "It is an interesting coincidence that the head-hunting Dyaks of Borneo have a house in the centre of their village, in an upper story of which they keep the heads which they capture suspended by a string which passes through a perforation in the top of the skull." The late lamented Prof. Wyman, in a letter written me the day before his death, emphatically states that the fact of this perforation was new to him; adding: "There is nothing of the kind in any of the skulls in our

museum, nor have I seen it mentioned as existing elsewhere." A friend has learned for me that an educated Indian makes the statement, in reply to our enquiry, that he remembers hearing his father say that formerly the heads of distinguished men and chiefs were honored by this mark after death.

The skull from the Sâble River is of a dark color, and its latitudinal or cephalic index, .770, would place it within the Orthocephalic or medium range; the altitudinal index being inferior, or exactly .745. The foramen magnum (contrary to the cranium of the North American Indian) has a central position, its index being .501. The two perfect specimens from the Rouge River are decidedly Brachycephalic, the cephalic indices being respectively .822 and .853, the altitudinal indices being inferior, or respectively .733 and .828, while the indices of the foramen magnum are, in one case .441, and in the other .507.

It is to be hoped that in thus calling attention to this singular custom, further information will be elicited; and I take this opportunity of earnestly soliciting the communication of any facts bearing on the subject, which I shall thankfully receive and duly acknowledge.

Since sending the foregoing to the NATURALIST, my attention has been called to a note in Harpers' Magazine for May, 1875, issued since my remarks were written, which states that "a communication made by Dr. Prunières (de Marvejols) before the meeting of the French Association for the Advancement of Science, at Lille, treated of the curious artificial perforations common among the neolithic skulls of the Lozère. These perforations vary, in the pieces exhibited, from an inch to an inch and a quarter in diameter. Near the perforated skulls were found rings of cranial bone, which seemed to be designed as amulets. These were evidently worked with flint tools. The men of the polished stone age practised trepanning; for if some of the skulls appear to have been perforated after death, others were treated during life, and the patients had lived for years afterward. One skull presented three perforations made near each other upon a line fore and aft. There is no distinction of age, the excisions occurring upon infants as well as upon adults. The motive of this strange custom was either medical or superstitious. They probably attributed disease to supernatural agencies. The evil spirit escaping through the opening made by the sorcerer, who wrapped the

operation in a shroud of mystery by preserving the detached piece as a precious relic. From the appearance of these facts reported by the learned archæologist of Lozère, he said that a new light had been shed upon the intellectual state of man in the polished stone age. It explained his religious conceptions, and confirmed the discovery of the figure of a goddess in the caverns of Baye (Marne). M. Broca remarked that perforated skulls were also found at the last named station. Among the skulls dug up by General Faidherbe were found two in the same condition. Dr. Chil, from the Canary Islands, said that perforated skulls had been found in the ancient burial-places of his country. Notice was also called to an example from the grotto of Lorde, upon which M. Hamy and M. Chaplain-Duparc gave some interesting details. A similarly perforated or trepanned skull was found by Mr. E. G. Squier among some ancient Peruvian crania collected by him."

The original report I have not seen; but the concluding remark, on the Peruvian skull, removes some doubt as to the kind of perforation described. In the well-known instance discovered by Mr. Squier, the character and the meaning of the operation (trepanning, the excision having been made during the lifetime of the individual) are so evident, and the shape (rectangular) and the position (on the left side of the frontal bone) so different from that of the perforations which I have described in the crania from Michigan, that I never for a moment associated them, and therefore made no reference to the Peruvian skull. The same view, we may presume, was taken by the learned persons to whom I referred my discoveries, who could scarcely be supposed ignorant of the case in question.

I find no positive statement as to the position of the perforations mentioned at the meeting of the French Association; but judge from certain remarks that (again unlike our instances from Michigan) there was no constant position observed. In certain cases of trepanning the position, of course, must have varied with the location of the injury to be operated on.

In short, the perforation which I find in the Michigan crania is exceptional—rarely present; it is simply a circular hole about half an inch (more or less) in diameter, apparently rudely bored, invariably in the top of the head of adults, and made after death; while those cases described in France, though only so recently

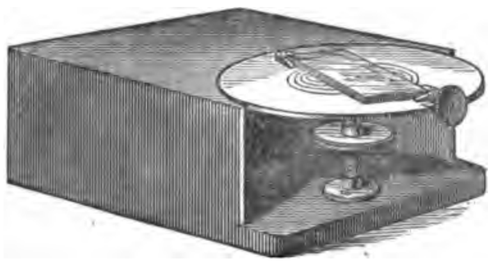
brought to notice, are quite numerous, and appear to be what may be more correctly termed trepanning, that is the part of the skull operated on was removed entire, and all ages are represented.

I have purposely refrained from much mention of my speculations on this custom of our aboriginal people; yet I have thought that the superstition of the modern North American Indian in regard to there being two souls, one of which visits the body after death, may throw some light on the subject. We know that the coverings of their graves, made of wood or bark, always have a perforation at one extremity for the supposed entrance and egress of the soul. But the question arises — Why, then, is not the perforation of the skull constant, or at least more frequent? — HENRY GILLMAN, *Detroit*, *Michigan*.

MICROSCOPY.

A NEW SELF-CENTRING TURN-TABLE. — Mr. C. F. Cox, of New York, has contrived a turn-table which centres the slide unerringly, and is at the same time a convenient working instrument. The slide is held, by pressure upon two diagonally opposite corners, between two clutches that are made, by a right and left screw, to move toward or from the centre simultaneously and at a uniform rate. The centre of revolution must therefore coincide with the centre

Fig. 210.



Cox's Self-centring Turn-table.

of the diagonal of the slide which is the exact centre of a truly rectangular slide, and is practically the centre of any slide fit to be used. This very useful piece of apparatus is, fortunately for the taste of its inventor and for the convenience of other microscopists, unencumbered by a patent; and it has been already constructed by Miller Bros. and by J. W. Queen & Co. The style made by the latter firm is figured in the accompanying cut.

For all new work, such as making varnish cells or centring cells or objects of any kind, this turn-table seems worthy to supersede all previous forms. For repairing old work, which may not be well centred originally, it should be provided with a spring clip under which a mounted object can be centred by the concentric circles in the usual manner, and which, when not in use, can be removed entirely from the table. By a general adoption of such a table much of the annoyance incidental to revarnishing slides would be avoided.

NOTES.

Prof. D. S. Jordan has prepared, for the Report for 1874 of the Indiana State Geological Survey, a preliminary list of the fishes which he has found in Indiana, also including those likely to be obtained in the waters of the state. This list is prepared for the purpose of inducing local collectors to examine the streams and lakes of the state. While all such local lists are much wanted, we think a mistake is made in using the "Key" system for the means of identification. Why is it not just as well to give the characters of the orders, families, genera and species, and thus teach the collector as he works out his specimens, instead of making him follow out a series of artificial gronps until he finds something that will answer to the specimen he has in hand. The labor by the last method is not lessened, and when the end is reached only a name is secured, whereas by the former method the name is found as readily, and much has been learned in hunting it out.

The Trustees of the Metropolitan Museum of Art (New York), have recently issued two instructive pamphlets, which also illustrate the riches in their keeping. One of these is a "Guide to the Cesnola Collection," and gives a general account, with a number of cuts, of this most valuable collection of ancient art from the excavations made on the Island of Cyprus. This collection was purchased by the Museum for about $50,000, and is the result of seven years labor on the part of General Cesnola, during which time over eight thousand Phœnician tombs were opened. These tombs were situated six and one-half feet below the more recent Greek tombs, and the most recent date given to them is about 800 or 1,000 years before Christ. The other, and much larger, pamphlet is a "Hand Book for the use of visitors examining Pot-

tery and Porcelain in the Museum," and contains much valuable information relative to both ancient and modern pottery.

The Peabody Museum of Archæology and Ethnology at Cambridge, has recently received from Mr. Alexander Agassiz, a very large and important collection made by himself and Mr. Garman during the past winter, and illustrating the archæology and ethnology of ancient and modern Peru. A large number of vases, several mummies, and articles of various kinds found in the graves, were obtained from ancient burial grounds near the coast. Some very interesting vessels were secured at Lake Titicaca, and a number of human crania were taken from the burial towers near the lake; while the collection of articles now in use by the Indians gives the means of comparing the past with the present. This very valuable addition will not be arranged until the cases in Boylston Hall, recently occupied by the Wyman Anatomical Museum, are fitted for the reception of the specimens belonging to the Peabody Museum.

Prof. H. A. Ward, of Rochester, has just issued a new catalogue of osteological preparations, which shows the immense facilities at his control in the way of furnishing skeletons, skulls and special preparations, to those who wish to obtain specimens for their own study or for schools and museums. Until Prof. Ward's establishment was started, Americans were dependent on Paris for such specimens, but now anything, from a skeleton of a man down to that of a fish, can be had at fair prices by sending to Rochester, New York.

The Cincinnati Quarterly Journal of Science for July contains a very readable article on the "Atlantis" tradition as given by Plato, and its bearing on the supposed early intercourse between the prehistoric civilizations of the old world and America. The author, Mr. L. M. Hosea, advocates the former relations between the ancient races of America and the old Egyptians, and points out many resemblances between the two civilizations.

In the forthcoming report by the State Geologist of Indiana, of which we have been favored with advance sheets, Professor Cox describes and gives plans of the several ancient works in Indiana of which mention was made in our last number. Professor Cox also describes and figures in the same report a number of Pipes of

the Mound builders, and he is entitled to much credit in thus making known the antiquities of the state.

The excursion of the Cambridge Entomological Club to the White Mountains started on July 8. About thirty persons, including ladies, will remain in camp for three or four weeks. The camp will be located near the Half-way House on Mt. Washington, and in an interesting field for collecting.

The Cincinnati Society of Natural History have recently received a bequest of $50,000 from Mr. Charles Bodman of Cincinnati. As no conditions are attached to the bequest the Society will be placed in a position that will enable it to do much for the advancement of science in the west.

At a recent meeting of the Trustees of the Peabody Academy of Science, Professor Gray, who was one of the original Trustees, withdrew from the board, and Dr. Coggswell of Bradford, and Mr. John Robinson of Salem, were elected to fill vacancies.

The distinguished geologist, Sir William Logan, for many years the head of the Geological Survey of Canada, died at Ontario, on June 28th.

BOOKS RECEIVED.

Report of Progress of the Mineralogical, Geological and Physical Survey of the State of Georgia, for the period from Sept 1, to Dec. 31, 1874. By George Little. 1875. pp. 36. 8vo.

Practical Hints on the Selection and Use of the Microscope. By John Phin. New York, 1875. pp 131. 8vo.

Cactus: Its History, Classification, Proving and Therapeutical Application. Read before the Eclectic Medical Society of the State of New York, Oct. 22, 1874. By Richard E. Kunze. Albany, 1875. pp. 33. 8vo.

Revue Scientifique de la France et de l'Etranger. 15, 29, Mai, 1875.

Academie Royale des Sciences, dec lettres et des Beaux Arts de Belgique. Memoires des Membres. Vol. 40. 1873. 4to. *Memoires couronnes et des savants etrangers.* Vols. 37, 38. 1873–74. 4to. *Memoires couronnes et autres memoires.* Vol. 23. 1873. 8vo. *Bulletins de l'Academie.* 2d series. Vols. 35, 36, 37. 1873–74. 8vo. *Annuaire de 1874.* 8vo.

Annales Meteorologiques de l'Observatoire Royal de Bruxelles. Annee 1872, 1873. 4to.

Congres International de Statisque. Par A. Quetelet. Bruxelles. 1873. 4to.

Academie Royale de Belgique. Observations des Phenomenes Periodiques pendant l'annee 1872. 4to.

La Comete de Coggia observee a Bruxelles. Par Ernest Quetelet. 8vo.

Les Observations Meteorologiques Simultanees sur l'Hemisphere Terrestre Boreal. Par Ernest Quetelet. 8vo.

Notices extraites de l'Annuaire de l'Observatoire Royal de Bruxelles pour 1874. Par A. Quetelet. 16mo.

Sitzungsberichte der math. naturw. 1874. I, Abtheil, Nos. 4, 5, 6, 7. II. Abtheil, Nos. 4, 5, 6, 7. III, Abtheil, 1-5, 6, 7.

Jahrbuch der k. k. geologischen Reichsanstalt. Wien, 1874. xxiv Band. 8vo.

Verhandlungen der k. k. geologischen Reichsanstalt. No. 16. 1874. 8vo.

Entomologische Zeitung. Herausgegeben von dem entomologischen Vereine zu Stettin. 1874. 8vo.

Bulletin de la Societe Vandoise des Sciences Naturelles. Lausanne, 1874. 2e S. Vol. xiii, No. 73. 8vo.

Annales de l'Institut Meteorologique de Norvege. Christiania, 1871, 1872, 1873, 1874.

Postola Sogur, Legendariske Fortællinger om Apostlernes Liv Deres Kamp for Kristendommens Udbredelse Samt Deres Martyrdod. By C. R. Unger. Christiania, 1874. pp. 966. 8vo.

Det Kongelige Norske Videnskabers Selskabs Skrifter i det 19 de Aarhundrede. 7th Band. Throndlyim 1872. pp. 240. 8vo.

Geologiske Undersgelser inden Troms Amt og tilgraendsende Dele af Nordlands Amt iv af Karl Pettersen. 8vo.

Index Scholarum in Universitate Regia Fredericiana Centesimo Vicesimo Eius Semestri Anno 1873, 1874, 1875. Christiania. 8vo.

On Giants' Caldrons. By S. A. Sexe. Christiania, 1874. 8vo.

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ADDRESS

OF

DR. JOHN L. LeCONTE,

THE RETIRING PRESIDENT OF THE ASSOCIATION.

GENTLEMEN AND LADIES OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE:—

THE founders of science in America, and the other great students of nature, who have in previous years occupied the elevated position in which I now stand, have addressed you upon many momentous subjects. In fulfilling the final duty, assigned to your Presidents by the laws of the Association, some have spoken to you in solemn and wise words concerning the duties and privileges of men of science: and the converse duties of the nation towards those earnest and disinterested promoters of knowledge. Others again have given you the history of the development of their respective branches of study, and their present condition, and have, in eloquent diction, commended to your gratitude those who have established on a firm foundation the basis of our modern systems of investigation.

The recent changes in our Constitution, by which you are led to expect from your two Vice-presidents, and from the Chairman of the Chemical Subsection, addresses on the progress made during the past year, restrain me from invading their peculiar fields of

labor, by alluding to scientific work which has been accomplished since our last meeting. While delicacy forbids me from so doing, I am equally debarred from repeating to you the brief sketch I endeavored to give at a former meeting[1] of the history, and present condition of Entomology in the United States.

But it has appeared to me that a few thoughts, which have impressed themselves on my mind, touching the future results to be obtained from certain classes of facts, not yet fully developed, on account of the great labor required for their proper comparison, may not be without value. Even if the facts be not new to you, I hope to be able, with your kind attention, to present them in such way as to be suggestive of the work yet to be done.

It has been perhaps said, or at least it has been often thought, that the first mention of the doctrine of evolution, as now admitted to a greater or less degree by every thinking man, is found in Ecclesiastes, i, 9 :—

"The thing that hath been is that which shall be; and that which is done is that which shall be done; and there is no new thing under the sun. Is there anything whereof it may be said, See, this is new? It hath been already of old time, which was before us."

Other references to evolutionary views in one form or another occur in the writings of several philosophers of classic times, as you have had recent cause to remember.

Whether these are to be considered as an expression of a perfect truth in the very imperfect language which was alone intelligible to the nation to whom this sacred book was immediately addressed on the one hand; and the happy guesses of philosophers, who by deep intuition had placed themselves in close sympathy with the material universe, on the other hand, I shall not stop to enquire. The discussion would be profitless, for modern science in no way depends for its magnificent triumphs of fact and thought upon any utterances of the ancients. It is the creation of patient intelligent labor of the last two centuries, and its results can be neither confuted nor confirmed by anything that was said, thought or done at an earlier period. I have merely referred to these indications of doctrines of evolution to recall to your minds that the two great schools of thought, which now divide philosophers, have existed from very remote times. They are,

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[1] Proceedings Am. Assoc. Adv. Sc. xxi (Portland).

therefore, in their origin, probably independent of correct scientific knowledge.

You have learned from the geologists, and mostly from those of the present century, that the strata of the earth have been successively formed from fragments more or less comminuted by mechanical action, more or less altered by chemical combination and molecular rearrangement. These fragments were derived from strata previously deposited, or from material brought up from below, or even thrown down from above, or from the débris of organic beings which extracted their mineral constituents from surrounding media. Nothing new has been added, everything is old: only the arrangement of the parts is new, but in this arrangement definite and recognizable unchanged fragments of the old frequently remain. Geological observation is now so extended and accurate that an experienced student can tell from what formation, and even from what particular locality these fragments have been derived.

I wish to show that this same process has taken place in the organic world, and that by proper methods we can discover in our fauna and flora the remnants of the inhabitants of former geologic times, which remain unchanged, and have escaped those influences of variation which are supposed to account for the differences in the organic beings of different periods.

Should I succeed in this effort, we will be hereafter enabled in groups of animals which are rarely preserved in fossil condition, to reconstruct, in some measure, the otherwise extinct faunæ, and thus to have a better idea of the sequence of generic forms in time. We will also have confirmatory evidence of certain changes which have taken place in the outline of the land and the sea. More important still, we will have some indications of the time when greater changes have occurred, the rock evidence of which is now buried at the bottom of the ocean, or perhaps entirely destroyed by erosion and separations. Of these changes, which involved connections of masses of land, no surmise could be made, except through evidence to be gained in the manner of which I am about to speak.

My illustrations will naturally be drawn from that branch of zoology, with which I am most familiar; and it is indeed to your too partial estimate of my studies in that science, that I owe the privilege of addressing you on the present occasion.

There are, as you know, a particular set of Coleoptera which affect the seashore; they are not very numerous at any locality, but among them are genera which are represented in almost every country of the globe. Such genera are called cosmopolitan, in distinction to those which are found only in particular districts. Several of these genera contain species which are very nearly allied, or sometimes in fact undistinguishable and therefore identical along extended lines of coast.

Now it happens that some of these species, though they never stray from the ocean shore inland, are capable of living upon similar beaches on fresh water lakes, and a few are found in localities which are now quite inland.

To take an example, or rather several examples together, for the force of the illustration will be thereby greatly increased.

Along the whole of the Atlantic, and the greater part of the Pacific coast of the United States, is found in great abundance on sand beaches, a species of Tiger-beetle, *Cicindela hirticollis*, an active, winged and highly predaceous insect; the same species occurs on the sand beaches of the great lakes, and were it confined to these and similar localities, we would be justified in considering it as living there in consequence solely of the resemblance in the conditions of existence. But, it is also found, though in much less abundance, in the now elevated region midway between the Mississippi and Rocky Mountains. Now, this is the part of the continent which, after the division of the great intercontinental gulf in Cretaceous times, finally emerged from the bed of the sea, and was in the early and middle Tertiary converted into a series of immense fresh water lakes. As this insect does not occur in the territory extending from the Atlantic to beyond the western boundary of Missouri, nor in the interior of Oregon and California, I think that we should infer that it is an unchanged survivor of the species which lived on the shores of the Cretaceous ocean, when the intercontinental gulf was still open, and a passage existed, moreover, towards the south-west, which connected with the Pacific.

The example I have given you of the geographical distribution of *Cicindela hirticollis* would be of small value, were it an isolated case; nor would I have thought it worthy of occupying your time, on an occasion like this, which is justly regarded as one for the communication of important truth. This insect, which I have selected as a type for illustrating the methods of investigation to

which I invite your attention, is, however, accompanied more or less closely by other Coleoptera, which like itself are not particular as to the nature of their food, so long as it be other living insects, and apparently are equally indifferent to the presence of large bodies of salt water. First, there is *Cicindela lepida*, first collected by my father, near Trenton, New Jersey, afterwards found on Coney Island, near New York, and received by me from Kansas and Wisconsin; not, however, found west of the Rocky Mountains. This species, thus occurring in isolated and distant localities, is probably in process of extinction, and may or may not be older than *C. hirticollis*. I am disposed to believe, as no representative species occurs on the Pacific coast, and from its peculiar distribution, that it is older. Second, there is *Dyschirius pallipennis*, a small Carabide, remarkable among other species of the genus by the pale wing covers, usually ornamented with a dark spot. This insect is abundant on the Atlantic coast from New York to Virginia, unchanged in the interior parts of the Mississippi valley, represented at Atlantic City, New Jersey, by a larger and quite distinct specific form, *C. sellatus*, and on the Pacific coast by two or three species of larger size and different shape, which in my less experienced youth I was disposed to regard as a separate genus *Akephorus*. This form is, therefore, in a condition of evolution,—how, I know not,—our descendants may. The Atlantic species are winged, the Pacific ones, like a large number of insects of that region are without wings.

Accompanying these are Coleoptera of other families, which have been less carefully studied, but I will not trespass upon your patience by mentioning more than two. *Bledius pallipennis* (*Staphylinidæ*) is found on salt marshes near New York, on the Southern sea coast, and in Kansas,—*Ammodonus fossor*, a wingless Tenebrionide, Trenton, seashore near New York, and valley of Mississippi at St. Louis; thus nearly approximating *Cicindela lepida* in distribution.

We can thus obtain by a careful observation of the localities of insects, especially such as affect seashore or marsh, and those which being deprived of their favorite surroundings, have shown, if I may so express myself, a patriotic clinging to their native soil, most valuable indications in regard to the time at which their unmodified ancestors first appeared upon the earth. For it is obvious that no tendency to change in different directions by "nu-

merous successive slight modifications"[1] would produce a uniform result in such distant localities, and under such varied conditions of life. Properly studied, these indications are quite as certain as though we found the well preserved remains of these ancestors in the mud and sand strata upon which they flitted or dug in quest of food.

Other illustrations of survivals from indefinitely more remote times I will also give you, from the Coleopterous fauna of our own country, though passing time admonishes me to restrict their number.

To make my remarks intelligible, I must begin by saying that there are three great divisions of Coleoptera, which I will name in the order of their complication of structural plan: 1. Rhynchophoræ; 2. Heteromera; 3. Ordinary or normal Coleoptera; the last two being more nearly allied to each other than either is to the first. I have in other places exposed the characters of these divisions, and will not detain you by repeating them.

From Palæontological evidence derived from other branches of zoology, we have a right to suppose, if this classification be correct, that these great types have been introduced upon the earth in the order in which I have named them.

Now, it is precisely in the first and second series that the most anomalous instances of geographical distribution occur; that is to say, the same or nearly identical genera are represented by species in very widely separated regions, without occurring in intermediate or contiguous regions. Thus there is a genus *Emeax*, founded by Mr. Pascoe, upon an Australian species, which, when I saw it, I recognized as belonging to *Nyctoporis*, a California genus, established many years before; and in fact barely specifically distinct from *N. galeata*. Two other examples are *Othnius* and *Eupleurida*, United States genera, which are respectively equivalent to *Elacatis* and *Ischalia*, found in Borneo. Our native genera *Eurygenius* and *Toposcopus*, are represented by scarcely different forms in Australia. All these belong to the second series (*Heteromera*), and the number of examples might be greatly increased with less labor on my part than patience on yours.

A single example from the Rhynchophora, and I will pass to another subject.

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[1] Origin of Species, 1869, 227.

On the sea coast of California, extending to Alaska, is a very anomalous insect, whose affinities are difficult to discern, called *Emphyastes fucicola*, from its occurrence under the sea-weed cast up by the waves. It is represented in Australia by several species of a nearly allied genus Aphela, found in similar situations.

In all entomological investigations relating to geographical distribution, we are greatly embarrassed by the multitude of species, and by the vague and opinionative genera founded upon characters of small importance. The Coleoptera alone, thus far described, amount to over 60,000 so-called species, and there are from 80,000 to 100,000 in collections. Under these circumstances it is quite impossible for one person to command either the time or the material to master the whole subject, and from the laudable zeal of collectors to make known what they suppose to be new objects, an immense amount of synonymy must result. Thus in the great Catalogus Coleopterorum of Gemminger and Harold, a permanent record of the untiring industry of those two excellent entomologists, species of the genus *Trechicus* founded by me upon a small North American insect, are mentioned under five generic names, only one of which is recognized as a synonym of another. These generic headings appear in such remote pages of the volume as 135, 146 and 289.

The two closely allied genera of Rhynchophora mentioned above are separated by no less than 168 pages.

It is therefore plain, that before much progress can be made in the line of research which I have proposed to you, whereby we may recover important fragments of the past history of the earth, Entomology must be studied in a somewhat different manner from that now adopted. The necessity is every day more apparent that descriptions of heterogeneous material are rather obstructive than beneficial to science, except in the case of extraordinary forms likely to give information concerning geographical distribution or classification. Large typical collections affording abundant material for comparison, for the approximation of allied forms, and the elimination of doubtful ones must be accumulated; and in the case of such perishable objects, as those we are now dealing with, must be placed where they can have the protecting influences both of climate and personal care.

At the same time, for this investigation, the study of insects is peculiarly suitable; not only on account of the small size, ease of collecting, and little cost of preserving the specimens, but because

from their varied mode of life in different stages of development, and perhaps for other reasons, the species are less likely to be destroyed in the progress of geological changes.[1] Cataclysms and submergences, which would annihilate the higher animals, would only float the temporarily asphyxiated insect, or the tree trunks containing the larvæ and pupæ to other neighboring lands. However that may be, I have given you some grounds for believing, that many of the species of insects now living existed in the same form before the appearance of any living genera of mammals, and we may suppose that their unchanged descendants will probably survive the present mammalian fauna, including our own race.

I may add, moreover, that some groups, especially in the Rhynchophora, which, as I have said above, I believe to bé the earliest introduced of the Coleoptera, exhibit with compact and definite limits, and clearly defined specific characters, so many generic modifications, that I am compelled to think that we have in them an example of the long sought unbroken series, extending in this instance from early mesozoic to the present time, and of which very few forms have become extinct.

I have used the word *species* so often, that you will doubtless be inclined to ask, what, then, is understood by a species? Alas! I can tell you no more than has been told recently by many others. It is an assemblage of individuals, which differ from each other by very small or trifling and inconstant characters, of much less value than those in which they differ from any other assemblage of individuals. Who determines the value of these characters? The experienced student of that department to which the objects belong. Species are, therefore, those groups of individuals representing organic forms which ARE RECOGNIZED as such by those who from natural power and education are best qualified to judge.

You perceive, therefore, that we are here dealing with an entirely different kind of information from that which we gain from the physical sciences; everything there depends on accurate observation, with strict logical consequences derived therefrom. Here the basis of our knowledge depends equally on accurate and trained observation, but the logic is not formal but perceptive.

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[1] For a fuller discussion of these causes, and of several other subjects which are briefly mentioned in this address, the reader may consult an excellent memoir by my learned friend, Mr. Andrew Murray, "On the Geographical Relations of the Chief Coleopterous Faunæ." (Journal of Linnæan Society, Zoology, Vol. xi.)

This has been already thoroughly recognized by Huxley[1] and Helmholtz,[2] and others, but we may properly extend the inquiry into the nature and powers of this æsthetic perception somewhat farther. For it is to this fundamental difference between biological and physical sciences that I will especially invite your attention.

Sir John Lubbock,[3] quoting from Oldfield[4] mentions that certain Australians "were quite unable to realize the most vivid artistic representations. On being shown a picture of one of themselves, one said it was a ship, another a kangaroo, not one in a dozen identifying the portrait as having any connection with himself."

These human beings, therefore, with brains very similar to our own, and as is held by some persons, potentially capable of similar cultivation with ourselves, were unable to recognize the outlines of even such familiar objects as the features of their own race. Was there any fault in the drawing of the artist? Probably not. Or in the eye of the savage? Certainly not, for that is an optical instrument of tolerably simple structure, which cannot fail to form on the retina an accurate image of the object to which it is directed. Where then is the error? It is in the want of capacity of the brain of the individual (or rather the race in this instance) to appreciate the resemblance between the outline, the relief, the light and shade of the object pictured, and the flat representation in color: in other words, a want of "artistic tact" or æsthetic perception.

A higher example of a similar phenomenon I have myself seen: many of you too have witnessed it, for it is of daily occurrence. It is when travellers in Italy having penetrated to the inmost chamber of the Temple of Art, even the Hall of the Tribune at Florence, stand in presence of the most perfect works of Art, which it has been given to man to produce, and gaze upon them with the same

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[1] "A species is the smallest group to which distinctive and invariable characters can be assigned." (Principles and Methods of Palæontology, Smithsonian Report, 1869, 378).

[2] "I do not mean to deny that, in many branches of these sciences, an intuitive perception of analogies and a certain artistic tact play a conspicuous part. In natural history . . . . . . it is left entirely to this tact, without a clearly definable rule, to determine what characteristics of species are important or unimportant for purposes of classification, and what divisions of the animal or vegetable kingdom are more natural than others." (Relation of the Physical Sciences to Science in General. Smiths. Report. 1871, 227.)

[3] Prehistoric Times, p. 440.

[4] On the Aborigines of Australia. Trans. Ethnological Soc. New Series, Vol. 3.

indifference that they would show to the conceptions of mediocre artists exhibited in our shops.

Perhaps they would even wonder what one can find to admire in the unrivalled collection, which is there assembled.

There is surely wanting in the minds of such persons that high, æsthetic sense, which enables others to enter into spiritual harmony with the great artists whose creations are before them.

Creations I said, and I use the word intentionally. If there is one power of the human soul, which more nearly than any other approaches the faculty of creation, it is that by which the almost inspired artist develops out of a rude block of stone, or out of such mean materials as canvass and metallic pastes of various colors, figures which surpass in beauty, and in power of exciting emotion, the objects they profess to represent.

Yet these unæsthetic and nonappreciative persons are just as highly educated, and in their respective positions as good and useful members of the social organism as any that may be found. I maintain only, they would never make good students of biology.

In like manner, by way of illustrating the foregoing observations, there are some, who in looking at the phenomena of the external Universe, may recognize only Chance, or the "fortuitous concourse of atoms," producing certain resultant motions. Others, having studied more deeply the nature of things, will perceive the existence of laws, binding and correlating the events they observe. Others again, not superior to the latter in intelligence, nor in power of investigation, may discern a deeper relation between these phenomena, and the indications of an intellectual or æsthetic or moral plan, similar to that which influences their own actions, when directed to the attaining of a particular result.

These last will recognize in the operations of nature the direction of a Human Intelligence, greatly enlarged, capable of modifying at its will influences beyond our control; or they will appreciate in themselves a resemblance to a superhuman intelligence which enables them to be in sympathy with its actions.

Either may be true in individual instances of this class of minds; one or other must be true; I care not which, for to me the propositions are in this argument identical, though in speculative discussions, they may be regarded as at almost the opposite poles of religious belief. All that I plead for is, that those who have not this perceptive power, and who in the present condition of

scientific discussion are numerically influential, will have tolerance for those who possess it; and that the ideas of the latter may not be entirely relegated to the domain of superstition and enthusiasm.

In the case of the want of perception of the Australian, a very simple test can be applied. It is only to photograph the object represented by the artist, and compare the outlines and shades of the photograph, with those of the picture. If they accord within reasonable limits the picture is correct to that extent; at least, however bad the artist, the human face could never be confounded with a ship, or a kangaroo.

Can we apply a similar test to the works of nature? I think we can. Suppose that man,—I purposely use the singular noun to indicate that all human beings of similar intelligence and education working towards a definite end, will work in a somewhat similar manner,—suppose, then I say, that man, endeavoring to carry out some object of importance, devises a method of so doing, and creates for that purpose a series of small objects, and we find that these small objects naturally divide and distribute themselves in age and locality, in a similar manner to that in which the species of a group of organisms are divided in space, and distributed in time; and that the results of man's labor are thus divided and distributed on account of the necessary inherent qualities of his intelligence and methods of action, is not the resemblance between human reason and the greater powers which control the manifestations of organic nature apparent?

I now simply present to you this investigation. Time is wanting for me to illustrate it by even a single example, but I feel sure that I have in the minds of some of you already suggested several applications of it to the principle I wish to teach:—the resemblance in the distribution of the works of nature to that of human contrivances evolved for definite purposes.

If this kind of reasoning commends itself to you, and you thus perceive resemblances in the actions of the Ruler of the Universe to those of our own race, when prompted by the best and highest intellectual motives, you will be willing to accept the declaration of the ancient text, "He doeth not evil, and abideth not with the evil inclined. Whatever he hath done is good;"[1] or that

[1] Desatir, p. 2.

from our own canon of Scripture: "With him is wisdom and strength, he hath counsel and understanding."[1]

The æsthetic character of Natural History, therefore, prevents the results of its cultivation from being worked out with the precision of a logical machine, such as with correct data of observation and calculation would be quite sufficient to formulate the conclusions of physical investigation. According as the perception of the relations of organic beings among themselves becomes more and more enlarged, the interpretation of these relations will vary within limits; but we will be continually approximating higher mental or spiritual truth.

This kind of truth can never be revealed to us by the study of inorganic aggregations of the universe. The molar, molecular and polar forces, by which they are formed, may be expressed, so far as science has reduced them to order, by a small number of simply formulated laws, indicative neither of purpose nor intelligence, when confined within inorganic limits. In fact, taking also the organic world into consideration, we as yet see no reason why the number of chemical elements known to us should be as large as it is, and go on increasing almost yearly with more minute investigations. To all appearance, the mechanical and vital structure of the universe would remain unchanged, if half of them were struck out of existence.

Neither is there any evidence of intelligence or design in the fact that the side of the moon visible to us exhibits only a mass of volcanoes.

Yet upon the earth, without the volcano and the earthquake, and the elevating forces of which they are the feeble indications, there would be no permanent separation of land and water; consequently no progress in animal and vegetable life beyond what is possible in the ocean. To us, then, as sentient beings, the volcano and the earthquake, viewed from a biological standpoint, have a profound significance.

It is indeed difficult to see in what manner the student of purely physical science is brought to a knowledge of any evidences of intelligence in the arrangement of the Universe. The poet, inspired by meditating on the immeasurable abyss of space, and the transcendent glories of the celestial orbs has declared,

"The undevout astronomer is mad,"

[1] Job, xii, 13.

and his saying had a certain amount of speciousness, on account of the magnitude of the bodies and distances with which the student of the stars is concerned. This favorite line is, however, only an example of what an excellent writer has termed "the unconscious action of volition upon credence," and it is properly in the correlations of the inorganic with the organic world, that we may hope to exhibit, with clearness, the adaptations of plan prefigured and design executed.

In the methods and results of investigation, the mathematician differs from both the physicist and the biologist. Unconfined like the former, by the few simple relations by which movements in the inorganic world are controlled, he may not only vary the form of his analysis, almost at pleasure, making it more or less transcendental in many directions, but he may introduce factors or relations, apparently inconceivable in real existences, and then interpret them into results quite as real as those of the legitimate calculus with which he is working, but lying outside of its domain.

If biology can ever be developed in such manner that its results may be expressed in mathematical formulæ, it will be the pleasing task of the future analyst, to ascertain the nature of the inconceivable (or imaginary as they are termed in mathematics) quantities which must be introduced when changes of form or structure take place. Such will be analytical morphology, in its proper sense; but it is a science of the future, and will require for its calculus a very complex algebra.

In the observation of the habits of inferior animals, we recognize many complications of action, which though directed to the accomplishment of definite purposes, we do not entirely comprehend. They are, in many instances, not the result of either the experience of the individual, or the education of its parents, who in low forms of animals frequently die before the hatching of the offspring. These actions have been grouped together, whether simple or complex, as directed by what we are pleased to call instinct, as opposed to reason. Yet there is every gradation between the two.

Among the various races of dogs, the companions of man for unnumbered centuries, we observe not only reasoning powers of a rather high order, but also distinct traces of moral sentiments, similar to those possessed by our own race. I will give no examples, for many may be found in books with which you are familiar.

Actions evincing the same mental attributes are also noticed in wild animals, which have been tamed. You will reply, that these qualities have been developed by human education; but not so, there must have been a latent capacity in the brain to receive the education, and to manifest the results by the modification of the habits. Now it is because we are vertebrates, and the animals of which I have spoken are vertebrates, that we understand, though imperfectly, their mental processes, and can develop the powers that are otherwise latent. Could we comprehend them more fully we would find, and we do find from time to time in the progress of our inquiries, that what was classed with instinct is really intellection.

When we attempt to observe animals belonging to another subkingdom, Articulata, for instance, such as bees, ants, termites, etc., which are built upon a totally different plan of structure, having no organ in common with ourselves, the difficulty of interpreting their intellectual processes, if they perform any, is still greater. The purposes of their actions we can only divine by their results. But anything more exact than their knowledge of the objects within their scope, more ingenious than their methods for using those objects, more complex, yet well devised than their social and political systems, it is impossible to conceive.

We are not warranted in assuming that these actions are instinctive, which if performed by a vertebrate we would call rational. Instead of concealing our ignorance under a word which thus used, comes to mean nothing, let us rather admit the existence here of a rational power, not only inferior to ours, but also different.

Thus proceeding, from the highest forms in each type of animal life to the lower, and even down to the lowest, we may be prepared to advance the thesis, that all animals are intelligent, in proportion to the ability of their organization to manifest intelligence to us, or to each other; that wherever there is voluntary motion, there is intelligence:— obscure it may be, not comprehended by us, but comprehended by the companions of the same low grade of structure.

However this may be, I do not intend to discuss the subject at present, but only wish in connection with this train of thought to offer two suggestions.

The first is, that by pursuing different courses of investigation in biology, we may be led to opposite results. Commencing with

the simplest forms of animal life, or with the embryo of the higher animals, it may be very difficult to say at what point intelligence begins to manifest itself; our attention is concentrated, therefore, upon those functions which appear to be the result of purely mechanical arrangements, acted upon by external stimuli. The animal becomes to our perception an automaton, and in fact, by excising some of the nervous organs last developed in its growth, we can render an adult animal an automaton, capable of performing only those habitual actions to which its brain, when in perfect condition, had educated the muscles of voluntary motion. On the other hand, commencing with the highest group in each type, and going downwards, either in structural complication, or in age of individual, it is impossible to fix the limit at which intelligence ceases to be apparent.

I have in this subject, as in that of tracing the past history of our insects, in the first part of this address, preferred the latter mode of investigation; taking those things which are nearest to us in time or structure, as a basis for the study of those more remote.

The second consideration is, since it is so difficult for us to understand the mental processes, whether rational or instinctive (I care not by what name they are called), of beings more or less similar, but inferior to ourselves; we should exercise great caution when we have occasion to speak of the designs of One who is infinitely greater. Let us give no place to the crude speculations of would-be-teleologists, who are indeed, in great part refuted already by the progress of science, which continually exhibits to us higher and more beautiful relations between the phenomenon of Nature "than it hath entered into the mind of man to conceive." Let not our vanity lead us to believe that because God has deigned to guide our steps a few paces on the road of truth, we are justified in speaking as if He had taken us into intimate companionship, and informed us of all His counsels.

If I have exposed my views on these subjects to you in an acceptable manner, you will perceive that in minds capable of receiving such impressions, biology can indicate the existence of a creative or directive power, possessing attributes, some of which resemble our own, and controlling operations which we may feebly comprehend. Thus far Natural Theology, and no farther.

What then is the strict relation of Natural History or biology to that great mass of learning and influence which is commonly

called Theology; and to that smaller mass of belief and action which is called Religion?

Some express the relation very briefly, by saying that Science and Religion are opposed to each other. Others again that they have nothing in common. These expressions are true of certain classes of minds; but the greater number of thinking and educated persons see, that though the ultimate truths taught by each are of quite distinct nature, and can by no means come in conflict, inasmuch as they have no point in common; yet so far as these truths are embodied in human language, and manipulated by human interests, they have a common dominion over the soul of man. According to the method of their government, they may then come into collision even as the temporal and spiritual sovereigns of Japan occasionally did, before the recent changes in that country.

In answering the query above proposed, it will be necessary to separate the essential truths of religion from the accessories of tradition, usage, and most of all, organizations and interpretations, which have in the lapse of time gathered around the primitive or revealed truth.

With the latter, the scientific man must deal exactly like other men, he must take it, or reject it, according to his spiritual gifts; but he must not, whatever be his personal views, discuss it or assail it *as a man of science*, for within his domain of investigation it does not belong.

With regard to the accessories of traditions, interpretations, etc., our answer may be clearer, when we have briefly reviewed some recent events in what has been written about as the Conflict of Religion and Science. Some centuries ago, great theological disgust was produced by the announcement that the sun and not the earth was the centre of the planetary system. A few decades ago profound dissatisfaction was shown that the evidence of organic life on the planet was very ancient. Recently some annoyance has been exhibited because human remains have been found in situations where they ought not to have been, according to popularly received interpretations; and yet more recently much apprehension has been felt at the possible derivation of man from some inferior organism; an hypothesis framed simply because in the present condition of intellectual advancement, no other can be suggested.

Yet all these facts, but the last, which still is an opinion, have been accepted, after more or less bitter controversy on both sides, and the fountain of spiritual truth remains unclouded and undiminished. New interpretations for the sacred texts, supposed to be in conflict with the scientific facts, have been sought and found without difficulty. These much feared facts have, moreover, given some of the strongest and most convincing illustrations to modern exhortation and religious instruction.

Thus, then, we see that the influence of Science upon Religion, has been beneficial. Scholastic interpretations founded upon imperfect knowledge, or no knowledge, but mere guess, have been replaced by sound criticism of the texts, and their exegesis in accordance with the times and circumstances for which they were written.

It must be conceded by fair minded men of both sides that these controversies were carried on at times with a rudeness of expression and bitterness of feeling now abhorrent to our usages. The intellectual wars of those days partook of the brutality of physical war, and the horrors of the latter, as you know, have been ameliorated only within very few years.

I fear that the unhappy spirit of contention still survives, and that there are yet a few who fight for victory rather than for truth. The deceptive spirit of Voltaire still buds forth occasionally; he, who, as you remember, disputed the organic nature of fossil shells, because in those days of schoolmen, their occurrence on mountains would be used by others as a proof of a universal Noachian deluge. The power of such spirits is fortunately gone for any potent influence for evil, gone with the equally obstructive influence of the scholastics with whom they formerly contended.

Since then, there is no occasion for strict Science and pure Religion to be in conflict, how shall the peace be kept between them?

By Toleration and Patience. Toleration towards those who believe less than we do, in the hope that they, by cultivation or inheritance of æsthetic perception, will be prepared to accept something more than Matter and Energy in the Universe, and to believe that Vitality is not altogether undirected Colloid Chemistry.

Toleration also towards those who, on what we think misunderstood or insufficient evidence, demand more than we are prepared to admit, in the hope that they will revise additional texts which

seem to conflict, or may hereafter conflict with facts deduced from actual study of Nature, and thus prepare their minds for the reception of such truths as may be discovered, without embittered discussions.

Patience, too, must be counselled. For much delay will ensue before this desired result is arrived at; patience under attack, patience under misrepresentation, but never controversy.

Thus will be hastened the time, when the glorious, all sufficient spiritual light, which though given through another race, we have adopted as our own, shall shine with its pristine purity, freed from the incrustations with which it has been obscured by the vanity of partial knowledge, and the temporary contrivances of human polity.

So, too, by freely extended scientific culture, may we hope that the infinitely thicker and grosser superstitions and corruptions will be removed, which greater age and more despostic governments have accumulated around the less brilliant, though important religions of our Asiatic Aryan relatives. These accretions being destroyed, the principal difficulty to the reception by those nations of higher spiritual truths will be obviated, and the intelligent Hindoo or Persian will not be tardy in recognizing in the pure life and elevated doctrine of the sincere Christian, an addition to, and fuller expression of religious precepts with which he is familiar. In this manner alone may be realized the hope of the philosopher, the dream of the poet, and the expectation of the theologian. A Universal Science, and a Universal Religion, coöperating harmoniously for the perfection of man and the glory of his Creator.

THE CROCODILE IN FLORIDA.

BY WM. T. HORNADAY.

In the warm, placid waters of tropical streams whose banks are bordered by reedy marshes and forests of perpetual green, is the home of the crocodile. About the middle of the day numbers may be seen lying lazily on the banks enjoying the heat, their polished scales shining in the sunlight, and all looking the very picture of tropical languor and repose. Its daily food is the

fishes that inhabit its native element, but many a bright-plumed water-fowl and unsuspecting quadruped falls a prey to its rapacity. Animals drinking at the stream's margin or swimming across are seized in the huge reptile's powerful jaws, dragged under water, drowned and devoured. The crocodile evinces a decided preference for tainted meat, and after capturing large prey it is often kept uneaten in the water until in a state of partial decomposition. The males are very pugnacious and often fight desperately for

Fig. 211.

Head of Florida Crocodile.

possession of the females. Sometimes an individual is captured whose tail is entirely gone, often the end is missing, sometimes a leg is wholly or partly wanting. Last winter we killed an alligator whose upper jaw was broken off squarely half way up to the eyes by some long previous accident.

The female crocodile lays from twenty to thirty eggs at a time. With her feet and nose she scoops a hole in the mud or sand on the shore, taking care to select a slightly elevated situation, and in this deposits her eggs in several layers, one upon another, placing a coat of earth, reeds and grass over each layer. The heat generated by the fermentation of this mass is sufficient to hatch the eggs in about thirty days.

While the crocodiles are distributed throughout all the southern hemisphere, in fact in all tropical regions, their cousins, the alligators, are confined to America; one species, the *A. Mississippensis* Gray, being especially abundant in the southern United States. It was formerly thought that the crocodile did not inhabit Australia, but it is now known to be there in respectable numbers, some specimens of great size having been captured. No one species of the *Crocodilidæ* is universally distributed, but the genus *Crocodilus* is widely known and has a greater range than any of its

congeners. The species are often confined to certain localities, and in a few their limits are very circumscribed.

The two American species of *Crocodilus*, viz., *rhombifer* and *acutus*, were first described by Cuvier as confined to the West Indies and South America, which view was accepted by naturalists for a long time. Subsequently the *C. acutus* has been discovered in different parts of Central America, and in 1870 Professor Jeffries Wyman described a skull from Florida as belonging to that species. Reports are current in Florida of a true crocodile existing there, but specimens have not been secured until very recently. The present year has thrown more light upon the subject by the capture of two fine specimens.

My personal observations on the subject were confined to the southeast coast of Florida, particularly the vicinity of Biscayne Bay. While there last winter collecting for the Museum of Prof. Ward, of Rochester, New York, I obtained sight of a reptile that I at first supposed to be a large alligator, but which a nearer view convinced me was a crocodile. After two unsuccessful attempts I succeeded in killing him by lying in wait for him with my rifle, opposite his favorite mud-wallow on the bank of the stream. It proved to be a male,—huge, old and ugly. His tenacity of life was surprising, and his frantic struggles in and out of water made the fight interesting for some time. He lived for quite an hour after six rifle-balls had been fired into his nape in the direction of the brain. He measured fourteen feet in length, and his girth at a point midway between fore and hind legs was five feet two inches. His teeth were large and blunt; his head rugose and knotty, with armor plates very large and rough, all conspiring to give him a very ugly and savage appearance. On dissection it was found that he had been very pugnacious, or else was a persecuted and unfortunate individual. Three of his teeth were more or less shattered; the tibia and fibula of the right hind leg had been broken in the middle and united, also one of the metatarsal bones of the same limb; about five inches had been bitten off the end of his tail leaving it quite blunt, and for some reason, probably an old wound, two of the vertebræ near the middle of the tail had grown together solidly at an awkward angle.

The day following the above capture (January 22, 1875) I had the further good fortune to kill at the same spot the mate of this crocodile, a beautiful female, measuring ten feet eight inches.

There was a striking contrast between the two specimens! The head of the female was regular in outline, comparatively smooth, teeth white, regular and sharp, plates even in surface and contour, and colors very marked. The entire under surface of both specimens was pale yellow, shading gradually darker up the sides with fine irregular streaks and spots of black. On the upper parts of the female through the entire length the black and yellow mottling was about uniform, the yellow rather predominating. The general appearance of the female was decidedly yellowish, while the back and tail of the male showed an almost entire absence of yellow, the prevailing color being a leaden, lustreless black. In brightness of color, smoothness of armor, and litheness of contour the female greatly outranked her rough and burly lord. The stomachs of both specimens were quite empty, but in the æsophagus of the male were the torn remains of two mud-hens in a state of disgusting decomposition. The ovary of the female contained four hundred and twenty eggs, varying from the size of No. 8 shot to a hen's egg, all perfectly spherical.

The exact locality of the captures was a narrow, very deep and crooked stream known as Arch Creek, flowing from the Everglades into the head of Biscayne Bay. While at Biscayne I collected abundant evidence that crocodiles, though rare, exist in various tributaries of the Bay. On the bank of Arch Creek, I found the skull, fifteen inches long, minus the lower jaw, of a crocodile belonging to the same species as the large specimens. No one could give me any information concerning it.

I succeeded in getting the perfect skull of a small specimen killed a few weeks before in Indian Creek, on the east side of the bay, quite near the seashore. Its length from occiput was seven and one-half inches. I was shown a small stuffed specimen fourteen and one-half inches in length, captured September 26, 1874, at the mouth of Miami River, ten miles farther down the bay. All the above specimens were taken in water that is brackish about half the time, being influenced by the tide. Prof. Ward has recently received a crocodile (skin and skeleton) from Lake Worth, Florida, ninety miles north of Biscayne Bay, which is of the same species as the foregoing. The skin measures nine feet ten inches.

In determining the species of these specimens I follow the late Dr. J. E. Gray, of the British Museum, as the best recent authority, his synopsis of recent crocodilians being the latest, most minute

and comprehensive. See Trans. Zool. Soc., 1867, vi, p. 125, *et seq.* Having been unable to examine the skull considered by Prof. Wyman it is impossible to give the differences between it and those in hand, but these latter certainly do not answer to any description of *C. acutus*, which at first I supposed them to be.

The following is Dr. Gray's description of *C. acutus*, and of the genus which he calls

"MOLINIA.—Face elongate; forehead swollen, convex, especially in the adult; orbits without any anterior ridge. Nuchal plates two or four, small. Cervical disc rhombic, of six plates, side plates generally small. The legs fringed with a series of triangular, elongate scales. Toes webbed. Scales of the forearm and thigh thin, smooth."

"Muzzle oblong, elongate, slender, with a swollen convexity on the middle of the face before the eyes. Nostril not separated by a long ridge; the internal nostril posterior with an oblong sloping opening; intermaxillary suture produced behind between the ends of the maxillæ."

"M. AMERICANA.—Face slender, dorsal plates irregular; the central series small, keeled; lateral scattered, strongly keeled. Nasal bones produced to the nostrils."

It is necessary to give the characteristics of the genus since a very few points are sufficient to distinguish the species of *Molinia* of which there are only two. I shall now describe specimens of which there is a series of six, varying from fourteen and one-half

Fig. 212.

Skull of Florida Crocodile. Side view.

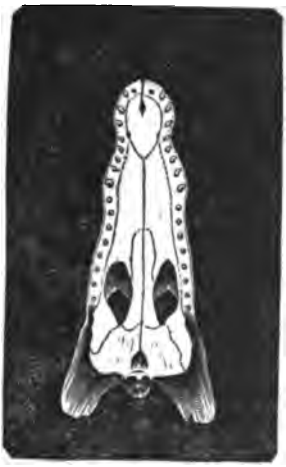
inches to fourteen feet in length. The description refers to the *adult* specimens, of which we have three.

Face elongate; forehead concave or flat; orbits without any anterior ridge. Nuchal plates four, small; three small keeled scales on each side of the neck between nuchal and cervical plates,

forming a row parallel to the row of nuchals, cervical disc rhombic, of six plates; legs fringed with a series of elongate scales. Toes of fore feet entirely free, the third and fourth hind toes partly united, and a very slight membrane between second and third. Scales of the forearm and thigh thick, and many convex or keeled. Dorsal plates in four longitudinal series; the vertebral series regular, large, average one-third broader than long, keeled; lateral series scattered, irregular hexagons, strongly keeled.

Muzzle elongate, broad in large specimens, with a high, swollen and prominent convexity on the middle of the face before the

Fig. 213.



Skull of Florida Crocodile. Under surface, showing outline of upper jaw.

Fig. 214. Fig. 215.

Upper surface of skull. 1, Florida Crocodile; 2, Alligator.

eyes. Nasal bones produced dividing the edges of the nostril; the intermaxillary suture produced behind between the ends of the maxillæ, the maxillary and intermaxillary bones pitted and tuberculated.

These specimens resemble the *C. acutus* and *C. rhombifer* Cuv. (*Molinia Americana* and *Palinia rhombifera* of Gray) in about an equal number of particulars, the main point of difference from the latter named species being the four rows of dorsal plates, of which the *rhombifer* has six. In fact these specimens seem to stand between the two species just mentioned, being equally related to each. The characters I have enumerated above seem distinctive,

and to indicate a new species for which I would propose the name *Crocodilus Floridanus*, or Florida Crocodile.

We present, for general illustration, a cut of the skull of an *Alligator Mississippensis* (Fig. 215) compared with the skull of a crocodile (Fig. 214). Both are from the same locality, Biscayne, Florida. The length of the alligator to which this skull belonged was nine feet ten inches, and that of the crocodile was ten feet eight inches, the figure being taken from the skull of the female here described.

I append the following measurements, in inches, of the three largest crocodile skulls. The first is that of the male 14 feet in length; the second that of the female 10 feet 8 inches in length; and the third, that of the Lake Worth specimen, 9 feet 10 inches in length.

Extreme length of head, ...	31½	21½	22
Length of skull from occiput, ...	24¾	18	18
Greatest width behind, ...	14½	9½	10
Width of forehead before, ...	5½	4	4
" " " behind, ...	7	4½	4¾
Breadth at notch, ...	4½	3	3
" " 10th tooth, following curve, . .	12¾	7⅝	7¾
" " 14th " " " .	13	8	9
Number of teeth above.	18	18	19
" " " below.	15	15	15

REVIEWS AND BOOK NOTICES.

GEOGRAPHICAL VARIATION IN COLOR AMONG SQUIRRELS.—We have previously, in papers by Messrs. R. Ridgway and J. A. Allen, presented our readers with the latest views on the subject of the geographical variation in size, proportions and color among North American birds, and now reproduce in part a recent paper by Mr. J. A. Allen on the same subject, particularly variations in color as applied to the squirrels of America north of Mexico, published in the "Proceedings of the Boston Society of Natural History" (vol. xvi, Feb. 4, 1874). This is a subject to which local collectors can very largely contribute by the transmission of marked varieties or specimens possessing any peculiarities in size, proportions or color to the Museum of Comparative Zoology at Cambridge or to the Smithsonian Institution, where they can be studied to the best advantage, as large numbers of the commonest

species are indispensable in studying the variation of animals. Regarding color variations we quote the following remarks:

"First, in respect to the increase in intensity of color from the north southward. Among the squirrels this increase is finely illustrated in *Sciurus Hudsonius* and in *Tamias striatus*, representatives of which from the southern parts of New York and Pennsylvania are much more highly colored than are those from northern New England and the British Provinces. *Sciurus Carolinensis* is perhaps a still more marked example, in which the color varies from the light pure gray of the upper parts in New England specimens, with a restricted pale yellowish brown dorsal area, to the rusty gray dorsal surface of the Florida type, in which the whole upper surface is usually strongly yellowish-rusty. This increase of color southward is, however, still more strongly marked in the fox squirrels of the Mississippi Basin, the so-called *Sciurus* "*ludovicianus*."

* * * * * * *

"The variations in color occurring in representatives of the same species at localities differing in longitude, is well shown in quite a number of groups. But few specific forms, however, have a sufficiently wide range to illustrate the variations that obtain along a given parallel throughout the whole breadth of the continent, the *Sciurus Hudsonius* group being the only instance among the squirrels. Others, however, show the transition that obtains in passing from the moist, fertile prairies of the Mississippi Valley to the dry plains, or from the deserts and mountainous districts of the interior to the moist region bordering the Pacific coast north of the parallel of 40°. *Spermophilus tridecem-lineatus* furnishes a good illustration of the differences in color that occur between representatives of the same species living on the moist, fertile prairies and those inhabiting the dry, barren plains, those from Illinois, Wisconsin, Minnesota and Iowa being much darker than those from Western Nebraska, Western Kansas and Colorado. Even specimens from Eastern Kansas are much darker than those from the middle and western portions of the same State. In this species the color is varied, in passing from the prairies to the plains, not only by the lighter shade of the dark ground color, but by the considerably greater breadth of the light spots and stripes in the specimens from the plains."

* * * * * * *

"But two of the most instructive and interesting groups of the *Sciuridæ*, in this connection, are those of which the common *Sciurus Hudsonius*, and *Tamias quadrivittatus* are respectively familiar examples, the former ranging over the northern half of the continent, and the latter extending over the western half of North America and Eastern Asia. In the *Sciurus Hudsonius* group, we have at the east the well-known chickaree (*S. Hudsonius*), extending westward to the Plains, and northwestward to Alaska, with its

brighter and smaller southern form in the eastern Atlantic States. On the arid plains of the Platte and Upper Missouri rivers it presents a markedly paler or more fulvous phase, well illustrated by specimens from the Black Hills. This form becomes even still paler and more fulvous at the eastern base of the main chain of the Rocky Mountains, between latitude 43° and 47°, where it begins to pass by insensible stages of gradation into the so-called *Sciurus Richardsoni* of the Rocky Mountains north of 45°, and the so-called *Sciurus Fremonti* of the Rocky Mountains south of about the same parallel. In the collections made in Western Wyoming, near the Yellowstone Lake, occur many specimens which are so exactly intermediate between the three forms (*S. Hudsonius*, *S. Richardsoni* and *S. Fremonti*) whose habitats here meet, that it is impossible to say which of the three forms they most resemble. At the same time specimens can be selected which will form a series of minute gradations from the pale form of *Hudsonius* from the Plains, on the one hand, to the *Richardsoni* and *Fremonti* forms on the other. To the southward of this district we soon pass into the region of the typical *Fremonti*, and to the westward and northward into the habitat of the *Richardsoni* type. Even the country about the sources of the Gros Ventres Fork of the Snake River, is already within the range of the true *Richardsoni*. The habitat of *S. Richardsoni* extends from the main chain of the Rocky Mountains, north of latitude 44°, to the Cascade Range. Here it becomes mixed with *S. Douglassi*, which scarcely differs from *S. Richardsoni*, except in being a little darker above, and in having the ventral surface more or less strongly tinged with buff, varying in different specimens from cinereous to pure buff. This form prevails from the Cascade Range to the Pacific Coast, southward to Northern California, and northward probably to Sitka. In Northern California the *S. Douglassi* meets the range of the true *S. Fremonti*, between which two forms there is here the most gradual and intimate intergradation. In this group we have hence four forms which, in their extreme phases of mutual divergence, appear as diverse as four good, congeneric species need to, but which, at points where their respective habitats join, pass into each other as gradually as do the physical conditions of the localities at which their extreme phases are developed.

The *Tamias quadrivittatus* group[1] presents an equally or even more striking range of variation in color, and also varies to an unusual degree in size. Beginning at the northward, we find that specimens from as far south as Pembina, and thence northward, are quite undistinguishable from specimens from Northeastern Asia, or the so-called *Tamias* "*Pallasi*" (*T. Pallasi* Baird=*T. striatus* of most European authors). This form is found to only a limited extent south of the northern boundary of the United

[1] *Tamias quadrivittatus*, *T. Pallasi*, *T. Townsendi* and *T. dorsalis* of American authors.

States, where on the plains of the Upper Missouri it passes into the blanched, pallid form of *T. quadrivittatus* (*T. quadrivittatus* var. *pallidus* nobis,—see beyond), and farther westward into the true *T. quadrivittatus* of the Rocky Mountains, and still further westward into the so-called *T. Townsendi* of the Pacific Coast. In this group the greatest pallor is reached on the plains of the Yellowstone, and in the deserts of Nevada, Utah and Arizona. In the central portions of the Rocky Mountains (Colorado and portions of New Mexico) a form is developed distinguished by its generally bright, strong colors, but especially for the rich fulvous tints of the sides of the body, to which there is but a slight tendency either in the northern form or the pallid form of the plains. Both, however, very gradually pass into the rufous-sided type, the pallid form wherever the plains approach the mountains (as along the eastern base of the Rocky Mountains, the Uintah, Sierra Nevada, and others of the more southern ranges), gradually becoming fulvous, while the darker northern form grades into the larger fulvous race of the more northern portions of the Rocky Mountains in Montana and Idaho. This larger fulvous race west of the main divide soon begins to assume a duller, more fuscous shade, deepening finally into the very fuscous form (*T. Townsendi*) of the region between the Cascade Range and the Pacific Coast. In this form the general color increases so much in depth as to become dusky yellowish-brown, and both the light and the dark stripes become obscure, and occasionally almost entirely obsolete, through the gradual accession of color. Between the extreme phase of this fuscous type and the extreme phase of the pallid type of the plains, in which the stripes are sometimes again partially obsolete through the extreme lightness of the general color, the differences are very great indeed. Yet in placing the scores of specimens I have had the opportunity of examining in a geographical series, or arranging them simply according to their localities, a most thorough and minute intergradation becomes at once apparent. The difference in size, too, between northern and southern specimens is also unusually great; the pale, southern form of the plains, and the extremely bright, fulvous form of Colorado and New Mexico, being very much smaller than the northern, darker form, or than the fuscous type of the northwest coast.

As corroborative evidence that these varied types of coloration are but geographical races, it becomes interesting to observe that the light and dark and the fulvous and rufous forms respectively, of the different species, occur over the same areas. With the fuscous type of *Tamias quadrivittatus* occur the dark types of *Sciurus Hudsonius*, and the dark-backed form of *Spermophilus grammurus*, and also a peculiar, dusky form of Arctomys and of Lepus, and a dark form of *Spermophilus Richardsoni*. On the plains occur pallid forms of *Sciurus* "*ludovicanus*," *Sciurus Hudsonius*, *Tamias quadrivittatus*, and *Spermophilus Richardsoni*.

With the fulvous type of *Tamias quadrivittatus* occurs a rufous of *Spermophilus grammurus;* but the form of *Sciurus Hudsonius* occurring over the same area, presents the exceptional condition of a minimum amount of rufous."

Respecting the mammals and birds of the continent as a whole, Mr. Allen recognizes at least five more or less well marked areas characterized by certain peculiarities of color variation, and finds a striking correlation between these areas and the prevalent tendencies of color-increase and the amount of aqueous precipitation:

"The first region we propose now to define is that of the Atlantic Slope, which will include not only the country east of the Alleghanies, but a large part of the British Possessions, extending westward at least as far as Fort Simpson, and thence northward and westward to Alaska, including, apparently, all of that territory north of the Alaska Mountains, with an annual rainfall throughout the whole of this extended region of about thirty-five to forty-five inches. Over this region (to which we may give the general term of *Atlantic Region*) the colors may be regarded as of the average or normal type, those of other regions being either of a diminished or increased intensity.

The second region will embrace the Mississippi Valley, or more properly the Mississippi Basin, and may hence be termed the *Mississippi Region.* Here the annual rainfall reaches forty-five to fifty-five inches, and over a small area east of the Lower Mississippi even exceeds sixty inches. The tendency here is so often to an increase of fulvous and rufous tints, that we may regard this as the distinctive chromatic peculiarity of the region, these tints reaching their maximum in the limited area of greatest humidity, but a general increase in intensity of color is also more or less characteristic of the region. A third region embraces the central portion of the Rocky Mountains, and being developed most strongly within the present territory of Colorado, and being also mainly included within that territory, may be termed the *Colorado Region.* The tendency here again, as compared with the immediately adjoining districts, is to a general increase of intensity of color, with also a marked inclination to the development of rufous and fulvous tints, this region being also within the influence of a comparatively high temperature, at least in summer. The humidity is here less than in either of the other regions already defined, the annual aqueous precipitation amounting to only about twenty-four to thirty inches; but it is yet greatly in excess of that of the districts immediately surrounding it.

The fourth region may be regarded as made up of the arid plains and deserts of the great central plateau of the Continent, including not only the "Great Plains," usually so called, but the

deserts and plains of Utah, Nevada, Western Colorado, New Mexico, Arizona and southwestward to Lower California, and may hence be appropriately termed the *Campestrian Region*. The annual rainfall is generally below fifteen inches, but ranges, at different localities, from three inches to twenty. Here a general paleness of color is the distinctive feature. The fifth region begins on the Pacific Coast at about the 40th parallel, embracing a comparatively narrow belt along the coast from Northern California to Sitka. Its peculiarities are most strongly developed west of the Cascade Range, north of 45°; they also prevail eastward nearly or quite to the main chain of the Rocky Mountains. It may hence be termed the *Columbian Region*. With an average annual rainfall of fifty-five to sixty-five inches, the prevalent tendency in color is to dusky and fuscous rather than rufous tints. The district between the Cascade Range and the main chain of the Rocky Mountains presents features that may almost entitle it to rank as a distinct region, as might also the region of maximum rainfall in the Mississippi Region. The southern half of Florida is also perhaps entitled to recognition as a distinct region, being characterized by excessive humidity and a subtropical intensity of color. It may also be necessary eventually to recognize as distinct districts the almost rainless portions of the Campestrian Region."

* * * * * * *

After looking at the subject in this broad way the reader need not feel surprised at the suppression of a good many nominal species. In 1857 Professor Baird reduced the number of species of Sciurus from twenty-four to ten, with two doubtful ones; Mr. Allen now reduces them to *five*, with seven geographical varieties in addition. The number of North American species of Sciuridæ in all is twenty-five.

BOTANY.

THE STARCH OF ZAMIA.—The roots of *Zamia pumila* yield a large per cent. of starch. The plant grows abundantly at the head of Biscayne Bay, Florida. I also found it, though not abundantly, at New Smyrna and Cedar Keys, Florida. The soil at the head of Biscayne Bay is full of loose pieces of limy rocks; between the interstices of these the plant grows; this kind of soil suits it best. The leaves have the general appearance of ferns; its roots are rough, of a gray color, and of the shape and size of parsnips. Not only is it abundantly reproduced from seed, but any piece left in the ground grows. It could be cultivated and made profitable.

The root yields two kinds of starch, white and yellow; also a poisonous substance. The white starch is very nutritious and makes excellent puddings, much nicer than sea moss, farina or corn starch; in fact, it is equal to any starch for domestic or manufacturing purposes. The yellow starch is much lighter than the white, and can be easily separated.

The roots yield a larger per cent. of white starch during the dry season, when the plant is at rest; when growing it produces more yellow starch. If used at this period a good slice is taken off the top and bottom, containing mostly yellow starch, which is feed to chickens and hogs. They, however, never get fat, as the substance contains but little nourishment. If the root is used in the dry or resting season, the very tip of the root is taken off, and a very thin slice with the leaves.

After the roots are washed clean and deprived of the necessary slice from top and bottom, they are then ground into a pulp, mixed with water and which is passed through a screen. This process carries off the poisonous matter as it is run off. The yellow, being so light and not adhesive to the white starch, is easily taken off. Both kinds dry easily in the sun. If the water and starch remain together long, fermentation takes place, and the two grades of starch will not separate. It is therefore best to grind the roots quickly, draw off the water and separate the starches promptly, as a pure white article is required for commerce.

The Seminole Indians make but little starch for sale; they have not the facilities for separating and drying; but they make a good deal for their own use, as they are not particular about leaving the less nutritious yellow with the white. The Indians make it into mush, either separate or mixed with flour; they also make bread of it, using the starch mixed with corn meal or flour. There are several mills among the white settlers of Biscayne Bay for the manufacture of this starch.

The seed of this plant is covered with a bright orange pulp, which, if eaten, has a dangerous narcotic effect. The leaves of the Zamia are the favorite food of that beautiful butterfly *Eumæus Atala*, which surpasses in beauty all other butterflies of Biscayne Bay; it is more numerous than any other; it is not exaggeration to say that it equals in number all the other species of butterflies in that region. They fly low, with a slow, measured motion,

alighting rather suddenly upon the leaves, are taken easily, as they are not shy nor easily disturbed. This plant is very common in the pine woods; often in botanizing I have seen but few other plants, consequently the Atala would be very numerous. Often three or four occur on one plant. Their eggs, well-matured pupæ, cocoons and caterpillars, are found upon the same plant.

This plant is commonly called Compte, and the starch goes by that name, while the Atala butterfly is called "Compte Moth." The inhabitants readily recognize the caterpillars, as they and their parent are unlike any other of the butterflies of Biscayne Bay. Several chrysalides were placed in a box, part of them had nearly completed their transformation, others were not so advanced. The first hatched in five days, the others in seven days. Whether they would have hatched in that time if left upon the plant is more than I can tell. I noticed this insect feeding upon the banana leaves in the gardens, but upon no other plant did it seem to feed, other than its natural one, the *Zamia pumila*. — E. PALMER.

ZOOLOGY.

ON AN UNDESCRIBED ORGAN IN LIMULUS, SUPPOSED TO BE RENAL IN ITS NATURE.[1]—In dissecting the king crab one's attention is directed to a large and apparently important gland, conspicuous from its bright red color contrasting with the dark masses of the liver and the yellowish ovary or greenish testes, and presenting the same appearance in either sex. The glands are bilaterally symmetrical, one situated on each side of the stomach and beginning of the intestine, and each entirely separate from its fellow. One of these glands consists of a stolon-like mass, running along close to the great collective vein, and attached to it by irregular bands of connective tissue, which also holds the gland in place. From this horizontal mass, four vertical branches arise, and lie between and next to the partitions at the base of the legs, dividing the sides of the body into compartments. The posterior of these four vertical lobes accompanies the middle hepatic vein from its origin from the great collective vein, and is sent off opposite the insertion of the fifth pair of feet. Half-way between the ori-

[1] Read at the Philadelphia Meeting of the National Academy of Sciences, held in Nov., 1874.

gin of the vein and the articulation of the foot to the body, it turns at a right angle, the ends of the two other lobes passing a little beyond it, and ends in a blind sac, less vertical than the others, slightly ascending at the end, which lies just above the insertion of the second pair of feet. The two middle lobes are directed to the collective vein. Each lobe is flattened out somewhat and lies close to the posterior wall of the compartment in which it is situated, as if wedged in between the wall, and the muscles between it and the anterior portion of the compartment. Each lobe also accompanies the bases of the first four tegumentary nerves. I could not by injection of the gland, make out any general opening[1] into the cavity of the body or any connection with the hepatic or great collective vein; any attempts to inject the gland from the veins failing. The four lobes certainly end in blind sacs. The lobes are irregular in form, appearing as if twisted and knotted, and with sheets and bands of connective tissue forming the sheaths of the muscles among which the gland lies. Each lobe, when cut across, is oval, with a yellowish interior and a small central cavity, forming, evidently, an excretory duct. The gland externally is of a bright brick red. The glandular mass is quite dense, though yielding. It is singular that this conspicuous gland, though it must have engaged their attention, has not been noticed by Van der Hoeven, Owen or A. Milne-Edwards in their accounts of dissections of this animal.

When examined under a Hartnack's No. 9 immersion lens and Zentmayer's B eye piece, the reddish external cortical portion consists of closely aggregated irregularly rounded nucleated cells of quite unequal size, and scattered about in the interstices between the cells are dark reddish masses which give color to the gland. They are very irregular in size and form, and twenty hours after a portion of the parenchyma was submitted to microscopic examination vibrated to and fro. I am reminded in the vibrating movements of these bodies, of Siebold's (Anatomy of the Invertebrates) description of similar bodies in the renal organs of the Lamellibranchs, *i.e.*, the gland of Bojanus. He says in a foot-note, p. 214 (Burnett's Translation), "If the walls of these organs are prepared in any way for microscopic examin-

[1] Leydig (Naturgeschichte der Daphniden) states that several anatomists, after laborious attempts, have failed to find the opening to the green gland in any crustacean.

ation, a part of their parenchyma separates into a vesiculo-granular mass, the particles of which have a very lively dancing motion. The motions are due to portions of ciliated epithelium adhering to the cells and granules."

In other portions of the outer reddish part of the gland, where the pigment (?) masses are wanting, the mass is made up of fine granular cells, not nucleated. Other cells have a large nucleus filled with granules and containing nucleoli.

In the yellowish, or, as we may for convenience call it, the medullary portion, are scattered about very sparingly what are probably the round secreting cells. The nucleus is very large and amber colored, with a clear nucleolus; others have no nucleolus, and the small ones are colorless.

I am at a loss to think what this gland with its active secreting cells, filled with a yellowish fluid, can be, unless it is renal in its nature. This view is borne out by the fact of its relation with the hepatic and great collective vein. If future examination shows some outlet into the venous circulation, then its renal nature would seem most probable. No other organ that can be renal in its nature exists in Limulus. In its general position and relations it is probably homologous with the green gland of the Decapod Crustacea, and its homologue in the lower orders of Crustacea, which is supposed also to be renal in its nature. It may also possibly represent the organ of Bojanus in the Mollusca, which is said to be renal in its function. It perhaps represents the glandular portion of the segmental organs in worms. That so large and important a gland is an embryonic gland, in adult life aborted and disused, is not probable, nor is there any good reason for regarding it as analogous to the suprarenal capsule of the vertebrates, analogues of which are said by Leydig to exist in Paludina and Pontobdella.

Reasoning from their histological structure, and by exclusion, it seems not improbable that these glands are renal in their nature and homologous with the green glands of the normal Crustacea.

They seem also homologous with the organs described by M. A. Giard in the Rhizocephala, and said by him to be "situated on each side of the middle part of the animal, and generally colored yellow or red (primitive kidneys?)." Annals and Mag. N. H., Nov., 1874, p. 383.

I may add that all these observations were made on living Lim-

ulus Polyphemus, in the laboratory of the Anderson School of Natural History at Penikese Island, Mass.—A. S. PACKARD, Jr.

BIRDS BREEDING ON PENIKESE ISLAND.—The following birds have been observed by me, breeding upon the island during the summer months of July and August, 1873, and '74.

Hirundo horreorum Wils. Barn swallow. Several nests have been found in the barn and beneath several old sheds, and may be called common.

Petrochelidon lunifrons Cab. Cliff swallow. One nest found on the outside of an old shed. Rare.

Cotyle riparia Boie. Bank swallow. A small colony on the northwest side of the Island in a small sand bank. Common or not rare.

Passerculus Savanna Bon. Savanna sparrow. Found breeding on the ground all over the Island. Common.

Pooecetes gramineus Bd. Grass finch, bay-winged bunting. Several nests have been taken. Not common but may be found more abundantly.

Melospiza melodia Bd. Song sparrow. Several nests have been found. Not rare.

Agelaeus pheniceus Vieill. Red-winged blackbird. Nests in the sedge grass, not very abundant, on the north shore of the larger Island. Not rare.

Sturnella magna Vieill. Meadow lark. Breeds in the fields of the larger Island in several places. Common.

Tyrannus Carolinensis Cuv. Kingbird, bee martin. One nest of four eggs was found by me in the bow of an old sail boat on the north side of the island in 1873; have seen none since.

Tringoides macularius Bon. Spotted sandpiper. A few pairs have been found breeding along the shores and in the grass near the shore. Common or not rare.

[*Tachycineta bicolor* was found breeding on the island in the summer of 1873, by Mr. A. S. Scott, as we are informed by Mr. C. O. Whitman.—EDS.]

Sterna hirundo Wils. Wilson's tern. Breeds abundantly all along the shores and in the grass near the shores.

Sterna paradisea Law. Roseate tern. Breeds with the former, but perhaps not quite so abundantly, but both breed by hundreds, though they are fast leaving for more secure quarters.

Sterna supercilliaris Vieill. Least tern. I add this on the authority of Mr. C. O. Whitman by whom a young bird was found, probably bred here in former years.[1]

Other forms may possibly be found, though owing to the smallness of the island I rather doubt it. — W. STEARNS.

PRAIRIE MICE. — Last fall, some boys out hunting, for lack of larger game, chased some prairie mice into an old stump. With the aid of the dog the stump was quickly demolished, exposing the winter quarters of some eight or ten mice. Two of the little fellows were captured alive; tied into a mitten and brought to me. They were placed in a tin box; in the evening the box was set on the table and the cover removed. The mice soon became so tame that they would leave their box, play over the table and take morsels of food from our hands; but they would never allow us to catch them. In fact that seemed an impossibility, although often attempted; our hands would invariably be found empty and the mice sitting on the opposite side of the table coolly washing their hands, seeming to enjoy our discomfiture. These mice had eyes and ears much larger than those of the house mouse; the hair on the throat, abdomen and feet, pure white. Their motions were all exceedingly quick, they never walked but darted or jnmped from one position to another. When performing their ablutions their comical appearance invariably excited laughter; one little paw would be moistened and drawn over the ears and face, so rapidly that it required sharp eyes to follow the motion, the other paw alternating till a satisfactory state of cleanliness was obtained. As a final touch to the toilet, the long, slender tail, was switched through the mouth from base to tip with lightning speed.

I observed one habit in our mice that I do not remember to have seen noticed before in any of the Muridæ. When frightened they would make a clear, quick, rattling noise, by alternately lifting their fore feet and vibrating them against whatever they were resting on. Occasionally a loosely folded paper was laid on the table for the mice to hide in; they sprung their rattle much more frequently when on the paper than when hiding behind books on the table; probably because they found the paper a better medium of sound than the solid table with its cloth cover. In a

[1] There were some twenty pair of this bird there last summer breeding.—T. M. B.

hollow log or stump, this noise probably proves an effectual means of communicating alarm to each other. After keeping our pets about three months they escaped from us; we never knew how or where; the lid was pushed from the box and they were gone.—J. M. MILLIGAN.

BEARS, ETC., IN ARIZONA.—In Dr. Coues' article on "The Quadrupeds of Arizona" (AM. NATURALIST, vol. 1, No. 7, p. 354), I find but two species of the Ursidæ mentioned as residents, and one *variety*, *U. horriœus*, as extending into Mexico. While attached to Lt. Wheeler's Expedition as Naturalist in 1871, I saw large numbers of bear skins amongst the Coyoté Apachés, then living at Camp Apaché in Eastern Arizona.

Black skins appeared most abundant, next grizzly, and occasionally that of the cinnamon bear. The latter hides were in such bad condition that I declined trading for them, although half a pound of "Army plug" would have secured one.

The Indians, as well as the officers at the Post, informed me that bears were abundant in the Mogollon Mts., but the former seldom attack a grizzly. Dr. Soulè, Post Surgeon, said, that while taking a horse-back ride up the wooded banks of the Rio del Sal one day, he suddenly came upon four large grizzly bears, and as they did not show any disposition to leave, he suddenly retraced his tracks to the Post. One large bear, of the same species also, upon another occasion had the curiosity to cross the ravine and go about the parade ground, until fired at by the sentinels, when he trotted off, threw himself over the precipice (on the river side of the post) into the water, swam across and disappeared amongst the pines.

At Bill Williams Mt., we shot one grizzly, and found numerous tracks around the springs. Wild Turkeys were occasionally seen, and as we approached Postal's Ranche, about twenty miles north of Ft. Whipple, we saw and chased several herds of Antelope. While in the mountains we also obtained five specimens of *Cervus macrotis* Say, which appeared rather abundant. There is another mammal, the beaver (*Castor Canadensis* Kuhl.), quite abundant near Camp Verde. Five miles northeast of the Post, Beaver creek contains numerous dams, and colonies of these animals and many pelts are annually collected, though a few years will suffice to exterminate a race, covering so small an area, and hemmed in by waterless deserts and rocky cañons.—W. HOFFMAN, M.D.

Albino Fishes.—Two interesting cases of albinism in fishes have recently fallen within my observation. The first was a specimen of the common haddock (*Melanogrammus æglefinus*), taken off Barnegat, N. J., May 7th, by the schooner "White Cloud," of New London, and shown to me by my friend, Mr. Blackford, of Fulton Market, New York. This fish, which was thirty-one inches long, was normal in every particular except in color. Its general hue was pinkish-white, with a pearly lustre, instead of the usual brownish-gray. The back and top of the head were slightly darker, approximating a very light salmon color. The black stripe which usually marks the lateral line and the blackish-brown blotch, behind and above the pectorals—the traditional mark of the thumb of the disciple Peter—were entirely absent. The fins throughout were yellowish white with a tinge of red, except the ventrals which were a shade darker. The slightest trace of the normal ashy tint of the belly might be discovered just below the origin of the pectorals.

The second instance is a specimen of the common eel (*Anguilla Bostoniensis*) taken in salt water at Noank, Conn., in December, 1874, and presented to the U. S. National Museum, by Capt. Elihu Potter. In this the color is a dull, pale yellow above, becoming nearly white beneath.

According to M. Dareste albinism is not uncommon among European eels. It appears, however, to be very exceptional in our waters. I have never seen or heard of an instance besides the case just cited. True albinism is especially uncommon among the members of the family to which the haddock belongs. The ground color of the cod and haddock varies much with the bottom on which they are taken, but I have never known of a case in which the spots and other markings were obliterated. A familiar instance of the influence of the color of the bottom is found in the rosy "rock-cod" of the coast of Maine, which is usually taken in the neighborhood of ledges covered with the bright red algæ such as *Ptilota serrata* and *Delesseria sinuosa*. In a similar manner the "butter-fish" (*Enneacentrus ouatalibi*) and the "grouper" (*Epinephelus fasciatus*) are influenced by the white coral-sand bottoms about the Bermuda Islands, but though they assume a very pallid hue, the character of their markings is quite unchanged.—G. Brown Goode, *University Museum, Middletown, Conn.*

[In the Fish collection of the Peabody Academy of Science there are examples of both of the above mentioned albinos. The haddock, agreeing with the description given by Prof. Goode, was taken off Newburyport some years ago, and sent to the Museum by Mr. Johnson of that place. The "white" eel was collected under the following peculiar circumstances: During the severe gale of Nov. 7, 1865, in Mass. Bay, a small *Cyclopterus* (lump fish) and the eel were washed aboard the schooner "Hero," Capt. Small, who found them on his deck after the gale and brought them to the Museum on his arrival at Salem the next day.—F. W. P.]

Chloral as a Preservative.—As it is very desirable that a substitute for alcohol be found for the purpose of preserving specimens, we copy the following from the New York "Tribune," trusting that trials of the experiment will be reported.

The "Philadelphia American Times" contains an article by Dr. W. W. Keen upon the anatomical, pathological, and surgical uses of chloral, in which he recommends this substance very strongly for the preservation of objects of comparative anatomy and natural history. It is used by injection into the blood vessels, or by immersion, and in his opinion it is likely to supersede many of the preparations now in use. Its special advantage is that the color of the object is preserved perfectly, and all the parts have a natural consistency, while there is nothing either poisonous or corrosive to affect the general health of the experimenter or to injure instruments.

For preserving a subject for dissection, half a lb. of chloral will suffice at a cost of a dollar or less. A solution for preserving specimens of natural history of ten or twelve grains to the ounce of water is quite sufficient, is much cheaper than alcohol, and the bottles instead of being hermetically sealed are closed by glass stoppers, or even ordinary corks. Dr. Keen has thus kept pus from various substances, and diseased growths of various kinds of other specimens for months, and found no change whatever in their character. Chloral is extremely antagonistic to fungi and infusoria, a very weak solution of it killing them instantly.

The deodorizing as well as the antiseptic properties of chloral are equal in Dr. Keen's opinion to those of any substance now known.

EXTRAORDINARY ALTERNATION OF GENERATIONS. — *Leptodera appendiculata* lives in *Arion ater* as larva (mouth and vent closed; tail with two long cuticular bands). If the snail is laid in water, or stimulated forcibly to muscular contractions, these small nematoids are expelled in great numbers, and rapidly develop in the water or any slimy substance; the bands are lost, mouth, genital orifice and vent become opened through the casting off of the entire cuticle, generative elements are developed and copulation takes place. The rapidly developing embryos do not attain the size of the parasitic generation, want the bands, and are in other respects unlike, but adopt the characters of the genus Rhabditis. They do not need any change of condition for attaining sexual maturity; they copulate, produce a third generation, etc. In this manner an indefinite series of generations may follow, until the nutritive substance is exhausted, when encystation takes place. The migration into the snail and the presumed transformation into the *Leptodera*-form of these encysted *Rhabditis* worms, was not observed. Between male and female individuals of the *Leptodera*- and *Rhabditis*-generation, no copulation will take place. There is some analogy (in spite of the great difference) between this extraordinary "alternation of generations" and that of *Ascaris nigrivenosa* Claus. — *Zoological Record for* 1872.

A TACHINA PARASITE OF THE SQUASH BUG.—It appears that the squash bug (*Coreus tristis*) is frequently infested by a maggot, the larva of a Tachina fly, as numerous specimens have been taken from the bodies of the males by Mr. Knollen, to whom we are indebted for specimens. The larvæ are very large, one specimen only occurring in the body of the Coreus, which seems apparently healthy, and performs its sexual functions in spite of the presence of so large a parasite. They are seldom found in the Hemiptera, though Pentatoma has been attacked by them.

DOUBLE MONSTERS.—M. Dareste, in reply to the discussion which his paper on double or twin monsters (as given in a former number) had called forth, explains the nature of the observations on which his deductions were based. It would appear that after submitting nearly 8,000 hens' eggs to the process of artificial incubation, he obtained nearly 4,000 anomalies or monstrosities, but of these only about thirty were double embryos or twin monstrosities. A similar result has been observed in the case of osseous

fishes; and Jacobi, who was the first to discover (in the course of the last century) the mechanism of fecundation among these fishes, had noted the proportion of twin monsters in fishes' eggs. His observations and those of Lereboullet coincide with the result obtained by M. Dareste, that while external conditions may often determine the formation of simple monsters, they are absolutely without effect in regard to the evolutions of double monstrosities. —*Nature.*

Importation of useful Insects.—At a recent meeting of the London Entomological Society, Mr. Dunning stated that he had received a communication from Mr. Nottidge, of New Zealand, asking if it were possible to send over humble-bees, in order, by means of cross fertilization, to procure seeds from clover, which plant remained infertile in the colony, failing suitable insect agency to aid its fertilization. It was suggested that by procuring a sufficient number of humble-bees when in a dormant condition, and keeping them in that state (by means of ice) during the voyage, the result might be obtained. Mr. McLachlan mentioned that he had received a letter from Capt. Hutton, from the same colony, stating that indigenous *Aphides* did not, apparently, exist there, but imported species were becoming very destructive, and he asked if it would be possible to import *Chrysopa.*—*Entomologist's Monthly Magazine, Jan.*, 1874.

Nesting of the Prairie Warbler in New Hampshire.—I obtained in northern New Hampshire, at the latitude of Mt. Washington (44½°), a nest of the prairie warbler, containing four eggs, which differ from all other specimens that I have ever seen. It is also a summer resident there, though Lynn, Mass., in 42½° latitude, has hitherto been generally accepted as the northern limit at which this bird breeds.—H. D. Minot.

GEOLOGY.

Elden Hole, Derbyshire.—We copy the following abstract from "Nature" of a paper read by Mr. R. Pennington before the Literary and Philosophical Society of Manchester, Jan. 26, as of interest in its bearing upon the formation of similar so-called bottomless pits in this country.

"Near the road from Buxton to Castleton, and about four miles from the latter place, stands Elden Hill, in the side of which is

Elden Hole, a perpendicular chasm in the rock, and, like many such apertures, reputed to be bottomless. The author describes a descent into the cavern, made by himself and others, on the 11th of September, 1873. At a distance of 180 feet from the top a landing-place was reached, although not a very secure one, as it was inclined at an angle of about 45°. Thence a cavern ran downwards towards the south or southeast; the floor was entirely covered with loose fragments of limestone, probably extending to a considerable thickness. There was quite sufficient light at this point to enable one to sketch or read. The party then scrambled, or rather slipped, into the cavern for some few yards, during which they descended a considerable distance: it was of a tunnel-like shape; then it suddenly expanded into a magnificent hall about one hundred feet across and about seventy feet high. The floor of this hall sloped like the tunnel, and like it was covered with *débris*. At the lower side they were about sixty feet below their landing-place, and therefore about two hundred and forty feet beneath the surface. The entire roof and walls of this cavern were covered with splendid stalagmitic deposits. From the roof were hung fine stalactites, whilst the sides were covered with almost every conceivable form of deposited carbonate of lime. In some places it was smooth and white as marble, in other places like frosted silver, whilst the rougher portions of the rock were clothed with all sorts of fantastic shapes glistening with moisture. From this cavern no opening of any length or depth was found save the one by which the party had entered it. There can be no doubt, the author believes, that this chasm has been formed by the chemical action of carbonic acid in water, and that it has attacked this particular spot either from the unusual softness of the rock originally situated here, or because there was here a joint or shrinkage in the strata. There is nothing, however, in the position of Elden Hole to lead one to suppose that any stream has ever flowed through it; no signs of such a state of things appear anywhere around. It is not related to any valley or ravine, or to any running water, and there is, as observed, an absence of any well-defined exit for water at the bottom. No mechanical action of a flowing stream can therefore have assisted the process of enlargement. The author thinks it must be due to the gradual silent solvent properties of rain-water falling on the surface, and escaping through jointings and insignificant channels in the hard rocks below. Whether the excavation took place from above or below is uncertain."

MICROSCOPY.

ATMOSPHERIC MICROGRAPHY.—To the already valuable contributions of Drs. Cunningham and Lewis, who were sent to India by the British government to investigate as thoroughly as possible the causes of cholera and other diseases prevalent there, there

is now added, from Calcutta, a memoir by Dr. Cunningham on "Microscopic Examinations of Air," which derives importance not less from the moderate and unprejudiced tone of the author than from his evident familiarity with the minute organisms involved in the investigations. In looking for some perceptible connection between the prevalence of certain forms of disease and the occurrence of any particular bodies in the air, the dust accumulated on shelves, etc., was avoided as too liable to error, and the solid particles were collected directly from the air by a modification of Dr. Maddox' apparatus, a glass slip painted with glycerine being arranged five feet above the ground in such a manner that the painted surface should be exposed vertically to a stream of air. Some sixty observations were made between February and September, 1872, including both dry and rainy seasons; and powers of from 400 to 1,000 were generally used. The following synopsis of microscopic deposits found is condensed from Rev. M. J. Berkley's review in the Quart. Jour. Mic. Science.

1. Particles of silicious matter.
2. Particles of carbonaceous matter.
3. Fragments of hair and other animal substances.
4. Fragments of cellular tissue of plants.
5. Pollen grains; of several common grasses, and a few of other plants. No seeds positively recognized.
6. Algæ, few; but besides "those lower genera which appear to be the early stages of lichens" (!) there were fragments of Oscillatoriæ, Desmidiaceæ, Closterium, and possibly Diatomaceæ.
7. Sporidia of lichens; frequent.
8. Spores or sporidia of fungi. These are by far the most abundant bodies; which is more remarkable by contrast with Ehrenberg's observations on the dust of the trade winds. Many of the fungoid organisms are easily referred to familiar genera, Macrosporium, Cladosporium, Sporidesmium, Puccinia, etc. Much the most common are sporidia of Spheriaceæ frequently in a state of germination, both in dry and hot seasons. True Torulæ do not appear to be present, but the yeast fungus, which after proof that it is nothing more than a condition of certain species of Penicillium, Aspergillus, and Mucor, is so often referred to Torula, or to Algæ, frequently occurs, either in scattered particles, or branched. Probably several of the bodies are spores of Myxogastræ, the Amæbæ which appear in certain specimens of pure rain water being

very probably the mere development of *Myxogastres*-spores, according to the well known observations of Prof. DeBary. Some spores of the higher fungi may possibly be recognized.

The air of sewers was repeatedly examined, taking care to exclude the external air (a probable source of error in some previous investigations), and only spores of Aspergillus and Penicillium were definitely recognized, these in half the cases being accompanied by Bacteria. The abundance of Bacteria, which are seldom recognizable in common atmospheric dust, accords with Cohn's observation on their conveyance by watery vapor, and suggests the theory that they are not absent or rare in common atmospheric air, but only so dry as to lose their characteristic appearance. They were present in pure rain water; and appeared abundantly when dry dust was added to fluids capable of putrefaction.

The author was able to trace no connection "between the numbers of bacteria, spores, etc., present in the air and the occurrence of diarrhœa, dysentery, cholera, ague, or dengue, nor between the presence or abundance of any special form or forms of cells and the prevalence of any of these diseases. The abundance and variety of fungus-spores in such an unexpected position are interesting, especially as so many of them were in a state of germination. As they would rarely be taken up by the air in this condition, and any possible germination on the slide during its twenty-four hours' exposure would not account for all the cases, Dr. Cunningham is inclined to believe that germination may take place while the spores are being wafted through the air.

Respecting the presence of pollen in the air, the editor of the "Quart. Journal of Microscopical Science" gives the following note on Mr. C. H. Blackley's interesting studies on the connection between the pollen grains of grasses and hay-asthma. "They were commenced in April, and continued till the end of July. In one series the air of a meadow at the average breathing level, 4 feet 9 inches from the ground, was examined. A slip of glass, coated with a thin layer of a non-drying liquid, was exposed horizontally. The daily results are tabulated. The highest number of pollen grains obtained on a surface of a square centimeter in twenty-four hours was 880 on June 28. Sudden diminutions in the quantity of pollen, when these occurred in the ascending scale between May 28 and June 28, were invariably due to a fall of rain, or to this and a fall in the temperature combined. The amount of pollen

in the higher strata of the atmosphere was examined by means of a kite, which being attached to other kites sometimes attained an elevation of 1000 feet. Pollen was found to be much more largely present at the upper levels than at the 'breathing level,' in the proportion, in fact, of 19 to 1. Abundant proof was obtained of the presence of fungoid spores in large quantities in the air. In one experiment the spores of a cryptogam, at 1,000 feet, were so numerous that they could not be counted; at a rough estimate they could not be less than 30–40,000 to the square inch. That these organized contents travel through the air to a considerable distance was proved by a series of experiments made in the outskirts of Manchester, but within the boundary of one of the most densely populated parts, and in no direction within less than one-third of a mile of grass land. The quantity of pollen was about one-tenth of that collected in the country."

NOTES.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—The twenty-fourth meeting of the Association was held in Detroit, Mich., beginning on Wednesday, August 11, and ending on Tuesday night following. In attendance, the meeting was not as large as the one preceding, about 170 members reporting themselves as present, in place of 225 the previous year; 96 new members were elected, while last year 118 elections were made. The falling off in attendance is unquestionably due to the want of arrangements with the railroads, by which the usual reduction in fares was not very generally secured, and to the late day at which the announcement relating to railroads was made. Perhaps in no previous year has the necessity for reduction in travelling expenses, caused by the general business depression, been so greatly felt as in the present one. As the cities inviting the Association to hold its meetings from year to year, do so in a most cordial manner, with the anticipation of large meetings, it becomes an important duty of the Local Committees that are formed every year to give the matter of transportation early attention. Railroad companies carry on their work by a complicated system of agencies, and it takes a long time to obtain the consent and issue of proper orders from the right parties. The companies, as a rule, are inclined to grant return passes to members attending the meetings, when the matter is properly laid before them, and

the way of attaining the desired end is by application of the Local Committee several months in advance of the meeting, so early in fact, as to allow the circular issued by the Committee being received by members during the month of June, before the general migration from places of residence takes place.

Of the 136 papers entered, 2 were read in General Session in full, and 2 by title, 1 was given as an evening lecture, 24 were read in Section A; 19 in the Sub-section of Chemistry; and 71 were read in Section B, including those of the Sub-section of Geology, formed on the last day of the meeting. Of the remaining 17 nothing was heard, and they were probably withdrawn by their authors or failed to pass the Several Committees.

The general character of the papers read was certainly above the average of many previous meetings, and the various Committees were well up to their work. The only drawback we noticed, being that of the formation of a Geological Sub-section on the last day, which resulted in a number of important papers being hastily read, or passed over by title, before a small audience. We think a great mistake is made by the Sections not agreeing on what Sub-sections are necessary on the first day, though not necessarily forming them until later in the meeting, and thus enable the Committees to so arrange the business as to give all the papers a fair chance. This could easily be done if members would make it a rule to enter their papers not later than the first day of the meeting. We understand that the feeling in the Standing Committee was very strong in favor of giving precedence, at future meetings, to those papers entered up to the first day, and as the Committee is now composed of so large a permanent body, the lessons taught at one meeting will not be lost at the following. An important move was made in forming a permanent Sub-section of Anthropology, on the principal of that of Chemistry in Section A. This will greatly relieve the pressure for time next year in Section B, and will undoubtedly be the means of bringing a very large number of Archæologists and Ethnologists to the next meeting.

The new constitution was thoroughly tested at the meeting and the business matters went on smoothly and saved much time for scientific work. We did not hear a word of complaint among the members in regard to the action of the present rules, and every one was evidently satisfied that under them the Association would move along with the least possible amount of friction. Several

of the past presidents were present, and their advice in the Standing Committee was evidently of great benefit. As alluded to in the closing remarks by President Hilgard, the several summer schools, and government and state surveying expeditions and special commissions, which are unusually numerous this year, prevented a number of the formerly constant attendants from taking part in the meeting, but as their work in the field shows what is being done to advance science, and as the results which they attain will, in part, naturally be brought before the next meeting, those present at the past meeting could not complain of the absence of many who were, nevertheless, much missed.

The citizens of Detroit did all that could be expected in the way of social entertainments, excursions, and provision for the meetings, though it was evident, as is often the case, where the Association goes for the first time, that they did not, in general, fully appreciate the importance of the meeting until it had been several days in operation. This was noticeable in the comparatively small attendance of citizens at the several sessions, though it is not to be questioned that quite a number were very much interested, and the seeds sown during the Association week will bear fruit in encouragement to the few workers who have so recently established the very promising and important "Scientific Association of Detroit," and it is certainly no small object gained for the advancement of science if the meetings of the Association thus tend to develop the formation of local societies for scientific research. While speaking thus of the citizens as a whole, it must not be supposed that the usual warm hearted welcome and appreciation, so characteristic of the west, was wanting in a number of gentlemen and ladies of Detroit who entered with spirit into the work and objects of the meeting. The very cordial welcome extended by Mr. Walker, on Wednesday morning, in behalf of the citizens, and the graceful remarks of Mr. Wells at the close of the meeting, both illustrated the interest in, and respect for, the objects which the Association has in view.

The address of the retiring President, Dr. LeConte, is printed in full in this number of the NATURALIST, and we propose to give those of the Vice Presidents in the next.

The results of the donation by Mrs. Thompson were presented to the meeting in the form of a printed quarto volume, containing a Monograph of Fossil Butterflies by Mr. Scudder, and was so

well received that the committee, who have had the matter in charge since the donation was made at the Portland meeting, must have felt satisfied with the performance of their duty.

As was naturally to be expected much feeling was evinced as to the next place of meeting, and the invitations received from Nashville, Philadelphia, and Buffalo were thoroughly discussed. The selection of Buffalo we think is most judicious, as all the benefits of the centennial year will be secured to the Association without the extra expense to the members and the reduction of Scientific work which the selection of Philadelphia would most likely have occasioned. Nashville was asked to keep its invitation open, as the feeling was very strong in favor of an early meeting there as due the Southern members, though for the next year it was felt that advantage should be taken of the great wave that would move from all parts of the country towards Philadelphia, and the meeting should therefore be located at some convenient point to that city. From the former meeting at Buffalo we have every reason to believe that the citizens will be alive to all that is expected of them for the centennial year, and for the quarter centennial (counting by meetings) of the Association, when the members will again assemble under the presidency of Prof. W. B. Rogers, of Boston, who called the Association to order at its first meeting in 1848.

The other officers for the next meeting are C. A. Young, of Hanover, Vice President of Sec. A; E. S. Morse, of Salem, Vice President of Sec. B; G. F. Barker, of Philadelphia, Chairman of Sub-section of Chemistry; L. H. Morgan, of Rochester, Chairman of Sub-section of Anthropology; T. C. Mendenhall, of Columbus, General Secretary; F. W. Putnam, of Salem, Permanent Secretary; A. W. Wright, of New Haven, Secretary of Sec. A; A. H. Tuttle, of Columbus, Secretary of Sec. B; T. T. Bouvé, of Boston, Treasurer. A committee was also appointed for the purpose of obtaining the presence of as many scientists as possible at the next meeting, and another committee was appointed to bring the formation of the Anthropological Sub-section before those specially interested in that department. In this way it is believed that the Association will secure a proper expression of science for the centennial year; and we understand that many of the citizens of Buffalo are resolved to make the meeting an extraordinary one in several particulars.

THE President and Fellows of Harvard College voted, some time since, to accept the fund accumulated by the Agassiz Memorial Committee for the use of the Museum of Comparative Zoölogy. In announcing the acceptance, President Eliot wrote:

"It will be a grateful duty for the President and Fellows, in executing the trust which the Committee have laid upon them, to commemorate the scientific attainments, enthusiasm and devotion of Prof. Agassiz, while they build up and enlarge the Museum of Comparative Zoölogy to the full proportions which his prophetic zeal imagined for it. The continuous growth of the museum is assured through the successful labors of the committee."

BOOKS RECEIVED.

Om Skuringsmærker, Glacial formationen, Terrasser og Strandlinier samt om grundfjeldets og sparagmitfjeldets mægtighed i Norge. By Theodor Kjerulf. II, Sparagmitfjeldet. Christiania, 1873. 4to.

The Land and Fresh Water Shells of La Salle County, Illinois. By W. W. Calkins. Chicago, 1874. Proceedings of the Ottawa Academy of Natural Sciences. pp. 48. 8vo.

Catalogue of Land and Fresh Water Shells. W. W. Calkins. Chicago, 1874. pp. 11. 8vo.

Bulletin de la Societe Geologique de France. 3me Serie, 3me Tome, No. 4. Paris, 1875.

Die Aegyptischen Denkmaler in St. Petersburg, Helsingfors, Upsala und Copenhagen. By J. Lieblein. Christiania, 1873. pp. 82. 8vo.

Enumeratio Insectorum Norvegicorum, Fas. 1. By H. Siebke. Christiania, 1874. pp. 72. 8vo.

The Third Annual Report of the Board of Managers of the Zoological Society of Philadelphia. 1875. pp. 33. 8vo.

Memoirs of the Geological Survey of India. Vol. i, Parts 2 & 3, and vols. ii-xi, 1. Calcutta. 8vo.

Palæontologia Indica. Series ii-x. 1. 4to.

Records of Geological Survey of India. Vols. i-vii. 8vo.

Society Entomologique de Belgique. Serie ii. No. 12, 13. 1875. 8vo.

The Journal of the Quekett Microscopical Club. London, March, 1875. No. 28. 8vo.

The Geological Magazine. London, May, 1875. Vol. ii, No. 5. 8vo.

Tidsskrift for Populære Fremstillinger af Naturvidenskaben. Copenhagen, 1875. Vol. ii, Part 2. 8vo.

Grevillea. London, 1875. No. 28. 8vo.

Hardwicke's Science Gossip. London. 1875. No. 126. 8vo.

Field and Forest. Devoted to General Natural History. Bulletin of the Potomac Side Naturalists' Club. Charles R. Dodge, Ed. Washington, 1875. Vol. i, No. 1. pp. 8. 8vo.

Circulars of Information of the Bureau of Education. Washington, 1875. Nos. 1 and 2. Pamphlets. 8vo.

Zoological Record for 1873. Vol. x. John Van Voorst. London. 8vo.

Seventh Annual Report on the Noxious, Beneficial and other Insects of the State of Missouri. By Charles V. Riley. Jefferson City, 1875. pp. 208. 8vo.

Eighth Annual Report of the Provost to the Trustees of the Peabody Institute of the City of Baltimore. Baltimore, 1875. pp. 43. 8vo.

Seventeenth Annual Report of the Board of Directors of the Mercantile Library Association of the City of Brooklyn. Brooklyn, 1875. pp. 24. 8vo.

Catalogus Specierum Generis Scolia. By Henricus de Saussure and Julius Sichel. Geneva, 1864. pp. 352. 8vo.

Circular No. 8, War Department, Surgeon-General's Office. A Report on the Hygiene of the United States Army, with Descriptions of Military Posts. Washington, 1875. pp. 625. 4to.

Notice Biographique sur Edouard-Rene Claparede. par Henri de Saussure. 1873. pp. 28. 4to.

Bulletin de l'Institut National Genevois. Geneva, 1875. Tome xx. pp. 304. 8vo.

Zeitschrift fur die Gesammten Naturwissenschaften. By C. G. Giebel. Berlin, 1874. Band x, Heft 7-12. 8vo.

Bulletin Mensuel de la Societe d'Acclimation. Paris. No. 11, 1874, No. 1, 1875. 8vo.

I. Travaux des membres de la Societe, De l'Utilite d'Introduire la Sericiculturea la Nouvelle Caledonie. By M. C. Raveret. Wattel.

Verhandlungen der k. k. Zoologisch Botanischen Gesselschaft in Wien. 1874. Band xxiv. pp. 626. 8vo.

The Monthly Microscopical Journal. London, 1875. June. 8vo.

Verhandlungen des Vereins fur Naturwissenschaftliche Unterhaltung zu Hamburg, 1873-1874. By J. D. E. Schmelt, 1875. pp. 191. 8vo.

Revue Scientifique. Paris. No. 50. 4to.

Northwestern Wyoming, including Yellowstone National Park. 1873. By William A. Jones Washington, 1875. pp. 337. 8vo.

The Geological Magazine. No. 132. London, June, 1875. 8vo.

Recollections of Sir Charles Lyell. Annual Presidential Address of Natural History Society of Montreal, for 1875. By Principal Dawson. pp. 8. 8vo,

On some new Fossil Ungulata. By E. D. Cope. pp. 8. 8vo.

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ADDRESS

OF

J. W. DAWSON.*

Of the leaders in Natural Science, the guides and teachers of some of us now becoming gray, who have in the past year been stricken by death from the roll of workers here, and have entered into the unseen world, two rise before me with special vividness on the present occasion:—Lyell, our greatest geological thinker, the classifier of the Tertiary rocks, the summer up of the evidence on the antiquity of man; but above all the founder of that school of geology which explains the past changes of our globe by those at present in progress; and Logan, the careful and acute stratigraphist, the explorer and establisher of the Laurentian system, and the first to announce the presence of fossil remains in those most ancient rocks. What these men did and what dying they left undone, alike invite us to the consideration of the present standpoint of Geological science, the results it has achieved and the objects yet to be attained; and I propose accordingly to select a small portion of this vast field and to offer to you a few thoughts in relation to it, rather desultory and suggestive however, than in any respect final. I shall therefore ask your attention for a short time to the question—"What do we know of the origin and history of life on our planet?"

This great question, confessedly accompanied with many difficul-

* Before the American Association for the Advancement of Science, at Detroit, 1875.

ties and still waiting for its full solution, has points of intense interest both for the Geologist and the Biologist. In treating of it here, it will be well, however meagre the result, to divest it of merely speculative views, and to present as far as possible the actual facts in our possession, and the conclusions to which they seem to point.

"If," says that greatest of uniformitarian geologists, who has so recently passed away, "the past duration of the earth be finite, then the aggregate of geological epochs, however numerous, must constitute a mere moment of the past, a mere infinitesimal portion of eternity." Yet to our limited vision, the origin of life fades away in the almost illimitable depths of past time, and we are ready to despair of ever reaching, by any process of discovery, to its first steps of progress. At what time did life begin? In what form did dead matter first assume or receive those mysterious functions of growth, reproduction and sensation? Only when we picture to ourselves an absolutely lifeless world, destitute of any germ of life or organization, can we realize the magnitude of these questions, and perceive how necessary it is to limit their scope if we would hope for any satisfactory answer.

I shall here dismiss altogether that form in which these questions present themselves to the biologist, when he experiments as to the evolution of living forms from dead liquids or solids — an unsolved problem of spontaneous generation which might alone occupy the whole time of this Section. Nor shall I enter on the vast field of discussion as to modern animals and plants opened up by Darwin and others. I shall confine myself altogether to that historical or palæontological aspect in which life presents itself when we study the fossil remains entombed in the sediments of the earth's crust, and which will enable me at least to show why some students of fossils hesitate to give in their adhesion to any of the current notions as to the origin of species. I may also explain that I shall avoid, as far as possible, the use of the term evolution, as this has recently been employed in so many senses as to have become nearly useless for any scientific purpose, and that when I speak of creation of species, the term is to be understood not in the arbitrary sense forced on it by some modern writers, but as indicating the continuous introduction of new forms of life under definite laws, but by a power not emanating from within themselves, nor from the inanimate nature surrounding them.

If we were to follow the guidance of those curious analogies which present themselves when we consider the growth of the individual plant or animal from the spore or the ovum, and the development of vegetable and animal life in geological time—analogies which, however, it must be borne in mind can have no scientific value whatever, inasmuch as that similarity of conditions which can alone give force to reasoning from analogy in matters of science, is wholly wanting—we should expect to find in the oldest rocks embryonic forms alone, but of course embryonic forms suited to exist and reproduce themselves independently.

I need not say to palæontologists that this is not what we actually find in the primordial rocks. I need but to remind them of the early and remarkable development of such forms as the Trilobites, the Lingulidæ and the Pteropods, all of them highly complex and specialized types, and remote from the embryonic stages of the groups to which they severally belong. In the case of the Trilobites, I need but refer to the beautiful symmetry of their parts both transversely and longitudinally, their division into distinct regions, the complexity of their muscular and nervous systems, their highly complex visual organs, the superficial ornamentation and microscopic structure of their crusts, their advanced position among Crustaceans, indicated by their strong affinities with the Isopods. All these characters give them an aspect far from embryonic, while, as Barrande has pointed out, this advanced position of the group has its significance greatly strengthened by the fact that in early primordial times we have to deal not with one species but with a vast and highly differentiated group, embracing forms of many and varied subordinate types. As we shall see, these and other early animals may be regarded as of generalized types but not as embryonic. Here then meets us at the outset the fact that in as far as the great groups of annulose and molluscous animals are concerned, we can trace these back no further than in a period in which they appear already highly advanced, much specialized and represented by many diverse forms. Either therefore these great groups came in on this high initial plane, or we have scarcely reached half way back in the life history of our planet.

We have here, however, by this one consideration attained at once to two great and dominant laws regulating the history of life. First, the law of continuity, whereby new forms come in

successively, throughout geological time, though as we shall see with periods of greater and less frequency. Secondly, the law of specialization of types, whereby generalized forms are succeeded by those more special, and this probably connected with the growing specialization of the inorganic world. It is this second law which causes the parallelism between the history of successive species and that of the embryo.

But there are great masses of strata known as Lower Cambrian, Huronian, Laurentian, which have made as yet few revelations as to the life which may have existed at the time of their deposition. In these rocks we know the problematical *Aspidella* of Billings from Newfoundland, the worm-burrows or Scolithus-like objects which occur in the Pre-silurian rocks of Madoc, the *Eozoon Bavaricum* of Gumbel, and the *Eozoon Canadense*, first made known by Logan, in the Laurentian of Canada. The first of these names represents a creature that may have been a mollusk, allied to Patella, or some obscure form of crustacean. The cylindrical holes called worm-burrows, are of course quite uncertain in their reference. They may represent marine worms in no respect different from those now swarming on our shores, or sponges, or corals, or sea-weeds. In any case they afford little help in explaining the teeming life of the primordial seas, and we can only hope that the vast thickness of sediments which has afforded these few traces of life may prove more fertile in the future. One slender beam of light in the darkness is, however, afforded by the *Eozoon Bavaricum* of Gumbel. If truly a fossil, this creature is closely connected with the still older *Eozoon* of the Laurentian. It therefore points backward to what is to us the dawn of life, but has no close link of connection with the succeeding fauna. On the other hand *Aspidella* and *Scolithus* may be held, if obscurely, to point forward. Thus the Huronian and early Cambrian become a period of transition from the Protozoa of the Laurentian to the higher marine life that succeeds—a passage to be more fully explained perhaps, and its great gaps filled by future discoveries; but which may, as in some later periods, be complicated with a contemporaneous transition from oceanic to shallow-water conditions in the localities open to exploration.

It will be observed that I take for granted the animal nature of Eozoon. If we reject this, we stand face to face with the bare, bald mystery of the abrupt manifestation of the Primordial fauna,

without even so much of preparation as may be supposed to arise from the previous appearance of Protozoa.

How then stand the facts as to the Proto-foraminifer? In answering this question, we should, I think, endeavor to divest ourselves of certain prejudices, and to give due weight to some probabilities and analogies which may in one way or another sway our opinion.

First, we must be prepared to find that those old crystalline rocks which we call Laurentian, have no real affinity with intrusive granites and other igneous masses, but are most nearly allied to modern sedimentary deposits. That the original chemical character of some of these ancient sediments may have differed to some extent from that of more modern sediments I do not doubt. Yet it is true that the more common of them, as the gneisses, diorites and mica-schists, consist of precisely the same elements which now appear in modern clays and sands, and that where local alteration has affected more modern rocks, we see these passing by insensible gradations into similar metamorphic beds. Farther when the old crystalline rocks are subjected to subaerial disintegration, they resolve themselves again into the most common sedimentary materials.

Another consideration here is the unequal manner in which sediments become altered according to their composition, and to the extent to which they are permeable by heated waters and vapors. For this reason, contiguous beds of rock will often be seen to differ very much in the degree of their alteration. Farther, some beds, and more especially limestones, continue to retain traces of organic structure long after these have perished from neighboring beds of different chemical composition. More especially when, in limestone, the cavities and pores of the fossils have been penetrated with other mineral matter, it would appear that nothing short of actual fusion will serve to obliterate them. Again, microscopic structures are often well preserved when the external forms have been lost, or are completely inseparable from the matrix, and in the present state of microscopical science there is little danger that in such specimens any experienced microscopist will fail to perceive the difference between organic and crystalline structures.

Having freed ourselves from misconceptions of these kinds, we may next turn to certain presumptions established by the consti-

tution of the Laurentian rocks, and the minerals contained in them.

The limestones of the Laurentian system are of great thickness and of vast geographical extent. Sir W. E. Logan has traced and measured three principal bands of these limestones, ranging in thickness from 60 to 1,500 feet, and traceable continuously in one district of Canada for more than one hundred miles, while their actual horizontal area must be enormously greater than this distance would indicate. These limestones are also associated with gneissose and schistose beds, exactly in the same way in which Palæozoic limestones are associated with sandstones and shales; and some of them are ordinary limestones, while others are more or less dolomitic, in which also they resemble the palæozoic limestones. Every geologist knows that the beds which in the succeeding geological periods are the representatives of these Laurentian limestones, are not only fossiliferous, but largely composed of the dèbris of oceanic organisms, and that it is to the purer and more crystalline beds that this statement most fully applies. May we not reasonably infer that the great Laurentian limestones are of similar origin.

One feature of these beds which has sometimes received a very different interpretation, I would here place in this connection. It is the association of Hydrous Silicates, and especially of Serpentine and Loganite, with the limestones, an association not universal but by no means uncommon in the Laurentian, and which may now be affirmed to occur throughout the whole series of marine organic limestones, up to the chalky foraminiferal mud now accumulating in the depths of the ocean. It is true that the silicates found in different formations differ somewhat in composition, but Dr. Sterry Hunt has shown that the Serpentines, Jollite, Loganite and the various Glauconites constitute a single series, whose members graduate into each other, and some of the modern Glauconites are not essentially distinct from the most ancient Serpentine.

This association is not accidental. It arises in the first place from the facility afforded for the combination of Silica with bases, arising from the presence of organic matter in the sea-bottom, and secondly from the abundance of soluble Silica in the hard parts of Diatoms, Radiolarians and Sponges, while these form the chief food of animals building their own skeletons of Carbonate of Lime, and consequently having no need of Silica. In this

point of view the Hydrous Silicates may be regarded as a sort of coprolitic matter, rejected by Foraminifera and other humble marine animals having calcareous skeletons. I hold, therefore, that the association of Serpentine and Loganite with the Laurentian limestones affords an additional reason for regarding them as organic, while it also explains the favorable conditions in which Foraminifera exist for the permanent preservation of the structures of their tests.

But again, there are vast quantities of Carbon in these limestones and the associated beds. The quantity of carbon in some large regions of the Lower Laurentian in Canada, is, as I have elsewhere shown, comparable with that in similar thicknesses of the Carboniferous system. But what geologist refers the carbon of the Palæozoic rocks to any other than an organic origin. True it is that this carbon of the Laurentian is in the state of graphite and destitute of organic structure; but this applies to similar material in other altered rocks, for example, to the graphitic shales of the Silurian of Eastern Canada and to the coal of Rhode Island.

Lastly, ought we not to attach some value to that generalization of Dr. Sterry Hunt, which affirms that the grand agent in the reduction and solution of the Peroxide of Iron has been organic matter. In this case what incalculable quantities of perished carbonaceous matter must be represented by the great beds of Magnetite in the Laurentian.

If, then, it is not unreasonable to believe that the Laurentian limestones may be of organic origin, the next question that occurs relates to the state of preservation in which the remains of such supposed organisms may occur. It would be conceivable that the process of crystalline rearrangement of particles might have proceeded so far as entirely to obliterate all traces of organic form or structure; but judging from other cases of altered limestones, this would be scarcely likely. In such limestones it is true, the fossils are often so obscure as to make little appearance on a fresh fracture of the stone, but they may present themselves distinctly on the weathered surfaces, in consequence of some difference either in resisting power or hardness, between the fossil and the matrix. In some cases also they can readily be developed by the action of an acid, and still more frequently their microscopic textures remain when the external forms are entirely concealed. There are

few crystalline marbles, once fossiliferous, that do not exhibit indications of their true nature in one or other of these ways.

It was precisely in the ways above indicated that *Eozoon Canadense* was first brought to light. The casts of its flattened chambers filled with Serpentine, Loganite or Pyroxene, project from the weathered surfaces of the Laurentian limestones, exactly as silicified Stromatoporæ do in the Silurian. Such specimens, collected by the explorers of the Canadian Survey, first gave the idea that there were fossils in these ancient rocks, and the microscope soon confirmed the indications afforded by external form, and demonstrated the place of the organism in the animal kingdom.

Into the description of the forms and structures of Eozoon it would be out of place to enter here. The details of these may be found in publications specially devoted to its description. I would merely insist on the entire conformity of the microscopic structures as I have myself examined and described them, and as they have been farther scrutinized by Dr. Carpenter and others best fitted to judge, with those of the calcareous tests of Foraminifera, and especially of the Nummuline group, and on the harmony of these structures with what the general considerations already referred to would lead us to expect.

It is, however, appropriate to our present subject, to inquire as to the position of Eozoon in the scale of animal existence, and its possible relations to preceding or succeeding types of life. With reference to these questions, it is obvious that we can predicate nothing as to the relation of our proto-foraminifers to the varied life of the Primordial or to any other group of animals than its own. We do not know that Eozoon was the only animal of its time. It may be merely a creature characteristic, like some of its successors, of certain habitats in the deep sea. Foraminifera have existed throughout the whole of geological time; but we have no positive evidence that any animal of this class has ever been transmuted into any other kind of creature. These considerations oblige us to restrict our inquiries to the relation of Eozoon to other forms of Foraminiferal life. We may the more excusably take this ground since even Hæckel, in his gastrula theory, has so strenuously maintained the distinctness of the Protozoa from all higher forms of life. Viewed in this way, we find that the proto-foraminifer was the greatest of all in point of magnitude, one of the most complex in regard to structure, compre-

hensive in type, as connecting the groups now recognized as the Nummulines and the Rotalines, and if inferior in anything only in less definiteness of habit of growth, a character in which it is paralleled by the sponges and other groups of higher rank. Thus if Eozoon was really the beginning of Foraminifers, this, like other groups in later times, appeared at first in one of its greatest and best forms, and its geological history consists largely in a gradual deposition from its high place as other and higher types little by little took its place; for degradation as well as elevation, belongs to the plan of nature. Eozoon here brings under our notice another phase of a creative law, which is corroborated by other forms of life in the succeeding periods. It is this. New types do not usually appear in their lowest forms, but in somewhat high if generalized species. The fact that Foraminifera, allied to Eozoon, have continued to exist ever since, introduces us to still another, namely, that though species and individuals die, any large group once introduced is very permanent, and may continue to be represented for the remainder of geological time.

But let us leave for the present the somewhat isolated case of Eozoon, and the few scattered forms of the Huronian and early Cambrian life, and go on further to the Primordial fauna. This is graphically presented to us in the sections at St. David's in South Wales, as described by Hicks. Here we find a nucleus of ancient rocks supposed to be Laurentian, though in mineral character more nearly akin to our Huronian, but which have hitherto afforded no trace of fossils. Resting unconformably on these is a series of partially altered rocks, regarded as Lower Cambrian, and also destitute of organic remains. These have a thickness of almost 1,000 feet, and they are succeeded by 3,000 feet more of similar rocks, still classed as Lower Cambrian, but which have afforded fossils. The lowest bed which contains indications of life is a red shale, perhaps a deep-sea bed, and possibly itself of organic origin, by that strange process of decomposition or dissolution of foraminiferal ooze, described by Dr. Wyville Thomson as occurring in the South Pacific. The species are two *Lingulellæ*, a *Discina* and a *Leperditia*. Supposing these to be all, it is remarkable that we have no Protozoa or Corals or Echinoderms, and that the types of Brachiopods and Crustaceans are of comparatively modern affinities. Passing upward through another 1,000 feet of barren sandstone, we reach a zone in which no less than

five genera of Trilobites are found, along with Pteropods and a sponge. Thus it is that life comes in at the base of the Cambrian in Wales, and it may be regarded as a fair specimen of the facts as they appear in the earlier fossiliferous beds succeeding the Laurentian. Taking the first of these groups of fossils, we may recognize in the *Leperditia* an ostracod Crustacean closely allied to forms still living in the seas and fresh waters. The *Lingulellæ*, whether we regard them as molluscoids, or with our colleague, Professor Morse, as singularly specialized worms, represent a peculiar and distinct type, handed down, through all the vicissitudes of the geological ages, to the present day. Had the Primordial life begun with species altogether inscrutable and unexampled in succeeding ages, this would no doubt have been mysterious; but next to this is the mystery of the oldest forms of life being also among the newest. One great fact shines here with the clearness of noon-day. Whatever the origin of these creatures, they represent families which have endured till now in the struggle for existence without either elevation or degradation. Here again we may formulate another creative law. In every great group there are some forms much more capable of long continuance than others. Lingula among the Brachiopods is a marked instance.

But when, with Hicks, we surmount the mass of barren beds overlying these remains, which from its unfossiliferous character is probably a somewhat rapid deposit of arctic mud, like that which in all geological time has constituted the rough filling of our continental formations, and have suddenly sprung upon us five genera of Trilobites, including the fewest-jointed and most many-jointed, the smallest and the largest of their race, our astonishment must increase, till we recognize the fact that we are now in the presence of another great law of creation, which provides that every new type shall be rapidly extended to the extreme limits of its power of adaptation.

Before considering these laws, however, let us in imagination transfer ourselves back to the Primordial age, and suppose that we have in our hands a living *Plutonia*, recently taken from the sea, flapping vigorously its great tail, and full of life and energy; an animal larger and heavier than the modern king-crab of our shores, furnished with all that complexity of external parts for which the crustaceans are so remarkable, no doubt with instincts and feelings and modes of action as pronounced as those of its

modern allies, and if Woodward's views are correct, on a higher plane of rank than the king-crab itself, inasmuch as it is a composite type connecting Limuli with Isopods. We have obviously here in the appearance of this great crustacean, a repetition of the facts which we met with in Eozoon; but how vast the interval between them in geological time, and in zoological rank. Standing in the presence of this testimony, I think it is only right to say that we possess no causal solution of the appearance of these early forms of life; but in tracing them and their successors upward through the succeeding ages, we may hope at least to reach some expressions of the laws of their succession, in possession of which we may return to attack the mystery of their origin.

First, it must strike every observer that there is a great sameness of plan throughout the whole history of marine invertebrate life. If we turn over the pages of an illustrated text-book of geology, or examine the cases or drawers of a collection of fossils, we shall find extending through every succeeding formation, representative forms of crustaceans, mollusks, corals, etc., in such a manner as to indicate that in each successive period there has been a reproduction of the same type with modifications; and if the series is not continuous, this appears to be due rather to abrupt physical changes; since sometimes where two formations pass into each other, we find a gradual change in the fossils by the dropping out and introduction of species one by one. Thus in the whole of the great Palæozoic Period, both in its Fauna and Flora, we have a continuity and similarity of a most marked character.

It is evident that there is presented to us in this similarity of the forms of successive faunas and floras, a phenomenon which deserves very careful sifting as to the question of identity or diversity of species. The data for its comprehension must be obtained by careful study of the series of closely allied forms occurring in successive formations, and our great and undisturbed Palæozoic areas in America, as Nicholson has recently pointed out, seem to give special facilities for this, which should be worked, not in the direction of constituting new species for every slightly divergent form, but in striving to group these forms into large specific types. The Rhynchonellæ of the type of *R. plena*, the Orthids of the type of *O. testudinaria*, the Strophomenæ of the types of *S. alternata* and *S. rhomboidalis*, the Atrypæ of the type of *A.*

reticularis, furnish cases in point among the Brachiopods. There is nothing to preclude the supposition that some of these groups are really specific types, with numerous race modifications. My own provisional conclusion, based on the study of Palæozoic plants, is that the general law will be found to be the existence of distinct specific types, independent of each other, but liable in geological time to a great many modifications, which have often been regarded as distinct species.

While this unity of successive faunæ at first sight presents an appearance of hereditary succession, it loses much of this character when we consider the number of new types introduced without apparent predecessors, the necessity that there should be similarity of type in successive faunæ on any hypothesis of a continuous plan; and above all, the fact that the recurrence of representative species or races in large proportion marks times of decadence rather than of expansion in the types to which they belong. To turn to another period, this is very manifest in that singular resemblance which obtains between the modern mammals of South America and Australia, and their immediate fossil predecessors—the phenomenon being here manifestly that of decadence of large and abundant species into a few depauperated representatives. This will be found to be a very general law, elevation being accompanied by the abrupt appearance of new types and decadence by the apparent continuation of old species, or modifications of them.

This resemblance with difference in successive faunas also connects itself very directly with the successive elevations and depressions of our continental plateaus in geological time. Every great Palæozoic limestone, for example, indicates a depression with succeeding elevation. On each elevation marine animals were driven back into the ocean, and on each depression swarmed in over the land, reinforced by new species, either then introduced or derived by migration from other localities. In like manner on every depression, land plants and animals were driven in upon insular areas, and on reëlevation again spread themselves widely. Now I think it will be found to be a law here that periods of expansion were eminently those of introduction of new specific types, and periods of contraction those of extinction, and also of continuance of old types under new varietal forms.

It must also be borne in mind that all the leading types of in-

vertebrate life were early introduced, that change within these was necessarily limited, and that elevation could take place mainly by the introduction of the vertebrate orders. So in plants, Cryptogams early attained their maximum as well as Gymnosperms, and elevation occurred in the introduction of Phænogams, and this not piecemeal, but as we shall see in the sequel, in great force at once.

Another allied fact is the simultaneous appearance of like types of life in one and the same geological period, over widely separated regions of the earth's surface. This strikes us especially in the comparatively simple and homogeneous life-dynasties of the Palæozoic, when for example we find the same types of Silurian Graptolites, Trilobites and Brachiopods appearing simultaneously in Australia, America and Europe. Perhaps in no department is it more impressive than in the introduction in the Devonian and Carboniferous Ages of that grand cryptogamous and gymnospermous flora which ranges from Brazil to Spitzbergen, and from Australia to Scotland, accompanied in all by the same groups of marine invertebrates. Such facts may depend either on that long life of specific types which gives them ample time to spread to all possible habitats, before their extinction, or on some general law whereby the conditions suitable to similar types of life emerge at one time in all parts of the world. Both causes may be influential, as the one does not exclude the other, and there is reason to believe that both are natural facts. Should it be ultimately proved that species allied and representative, but distinct in origin, come into being simultaneously everywhere, we shall arrive at one of the laws of creation, and one probably connected with the gradual change of the physical conditions of the world.

Another general truth, obvious from the facts which have been already collected, is the periodicity of introduction of species. They come in by bursts or flood-tides at particular points of time, while these great life-waves are followed and preceded by times of ebb in which little that is new is being produced. We labor in our investigation of this matter under the disadvantage that the modern period is evidently one of the times of pause in the creative work. Had our time been that of the early Tertiary or early Mesozoic, our views as to the question of origin of species might have been very different. It is a striking fact, and in illustration of this, that since the glacial age no new species of mammal can

be proved to have originated on our continents, while a great number of large and conspicuous forms have disappeared. It is possible that the proximate or secondary causes of the ebb and flow of life production may be in part at least physical, but other and more important efficient causes may be behind these. In any case these undulations in the history of life are in harmony with much that we see in other departments of nature.

It results from the above and the immediately preceding statement, that specific and generic types enter on the stage in great force and gradually taper off toward extinction. They should so appear in the geological diagrams made to illustrate the succession of life. This applies even to those forms of life which come in with fewest species and under the most humble guise. What a remarkable swarming, for example, there must have been of Marsupial Mammals in the early Mesozoic, and in the Coal formation the only known Pulmonates, four in number, belong to as many generic types.

I have already referred to the permanence of species in geological time. I may now place this in connection with the law of rapid origination and more or less continuous transmission of varietal forms. I may, perhaps, best bring this before you in connection with a group of species with which I am very familiar, that which came into our seas at the beginning of the Glacial age and still exists. With regard to their permanence, it can be affirmed that the shells now elevated in Wales to 1,200, and in Canada to 600 feet above the sea, and which lived before the last great revolution of our continents, a period vastly remote as compared with human history, differ in no tittle from their modern successors after thousands or tens of thousands of generations. It can also be affirmed that the more variable species appear under precisely the same varietal forms then as now, though these varieties have changed much in their local distribution. The real import of these statements, which might also be made with regard to other groups, well known to palæontologists, is of so great significance that it can be realized only after we have thought of the vast time and numerous changes through which these humble creatures have survived. I may call in evidence here a familiar New England animal, the common sand clam, *Mya arenaria*, and its relative *Mya truncata*, which now inhabit together all the northern seas; for the Pacific specimens, from Japan and

California, though differently named, are undoubtedly the same. *Mya truncata* appears in Europe in the Coralline Crag, and was followed by *M. arenaria* in the Red Crag. Both shells occur in the Pleistocene of America, and their several varietal forms had already developed themselves in the Crag, and remain the same to-day; so that these humble mollusks, littoral in their habits, and subjected to a great variety of conditions, have continued perhaps for one or two thousand centuries to construct their shells precisely as at present. Nor are there any indications of a transition between the two species. I might make similar statements with regard to the Astartes, Buccinums and Tellinæ of the drift, and could illustrate them by extensive series of specimens from my own collections.

Another curious illustration is that presented by the Tertiary and modern faunæ of some oceanic islands far separated from the continents. In Madeira and Porto Santo, for example, according to Lyell, we have fifty-six species of land shells in the former, and forty-two in the latter, only twelve being common to the two, though these islands are only thirty miles apart. Now in the Pliocene strata of Madeira and Porto Santo we find thirty-six species in the former, and thirty-five in the latter, of which only eight per cent. are extinct, and yet only eight are common to the two islands. Further there seem to be no transitional forms connecting the species, and of some of them the same varieties existed in the Pliocene as now. The main difference in time is the extinction of some species and the introduction of others without known connecting links, and the fact that some species, plentiful in the Pliocene, are rare now and vice versa. All these shells differ from those of modern Europe, but some of them are allied to Miocene species of that continent. Here we have a case of continued existence of the same forms, and in circumstances which the more we think of them the more do they defy all our existing theories as to specific origins.

Perhaps some of the most remarkable facts in connection with the permanence of varietal forms of species, are those furnished by that magnificent flora which burst in all its majesty on the American continent in the Cretaceous period, and still survives among us even in some of its specific types. I say survives; for we have but a remnant of its forms living, and comparatively little that is new has probably been added since. The confusion which

obtains as to the age of this flora, and the discussions in which Newberry, Heer, Lesquereux and recently Mr. G. M. Dawson, have taken part, obviously arise, as the latter has I think conclusively shown, from the fact that this modern flora was in its earlier times contemporary with Cretaceous animals, and survived the gradual change from the animal life of the Cretaceous down to that of the Eocene and even of the Miocene. In a collection of these plants from what may be termed beds of transition from the Cretaceous to the Tertiary, I find among other modern species two recent ferns most curiously associated. One is the common *Onoclea sensibilis*, found now very widely over North America, and which in so-called Miocene times lived in Europe also. The other is *Davallia tenuifolia* of Eastern Asia—a fern not now even generically represented in North America, but still abundant on the other side of the Pacific. These little ferns are thus probably older than the Rocky Mountains and the Himalayas, and reach back to a time when the Mesozoic Dinosaurs were becoming extinct and the earliest Placental mammals being introduced. Shall we say that these ferns and along with them our two species of American Hazel and many other familiar plants, have propagated themselves unchanged for half a million of years?

Take from the western Mesozoic a contrasting yet illustrative fact. In the Jurassic or Cretaceous rocks of Queen Charlotte's Island, Mr. Richardson, of the Canadian Survey, finds Ammonites and allied cephalopods similar in many respects to those discovered further south by your California survey, and Mr. Whiteaves finds that some of them are apparently not distinct from species described by the Palæontologists of the Geological Survey of British India. On both sides of the Pacific these shells lie entombed in solid rock, and the Pacific rolls between as of yore. Yet these species, genera and even families, are all extinct—why, no man can tell, while land plants that must have come in while the survivors of these cephalopods still lived, reach down to the present. How mysterious is all this, and how strongly does it show the independence in some sense of merely physical agencies on the part of the manifestations of life.

Such facts as those to which I have referred, and many others which want of time prevents me from noticing, are in one respect eminently unsatisfactory, for they show us how difficult must be any attempts to explain the origin and succession of life. For

this reason they are quietly put aside or explained away in most of the current hypotheses on the subject. But we must as men of science face these difficulties, and be content to search for facts and laws even if they should prove fatal to preconceived views.

A group of new laws, however, here breaks upon us. (1) The great vitality and rapid extension and variation of new specific types. (2) The law of spontaneous decay and mortality of species in time. (3) The law of periodicity and of simultaneous appearance of many allied forms. (4) The abrupt entrance and slow decay of groups of species. (5) The extremely long duration of some species in time. (6) The grand march of new forms landwards, and upwards in rank. Such general truths deeply impress us at least with the conclusion that we are tracing, not a fortuitous succession, but the action of power working by law.

I have thus far said nothing of the bearing of the prevalent ideas of descent with modification, on this wonderful procession of life. None of these of course can be expected to take us back to the origin of living beings; but they also fail to explain why so vast numbers of highly organized species struggle into existence simultaneously in one age and disappear in another, why no continuous chain of succession in time can be found gradually blending species into each other, and why in the natural succession of things, degradation under the influence of external conditions and final extinction seem to be laws of organic existence. It is useless here to appeal to the imperfection of the record or to the movements or migrations of species. The record is now in many important parts too complete, and the simultaneousness of the entrance of the faunas and floras too certainly established, and moving species from place to place only evades the difficulty. The truth is that such hypotheses are at present premature, and that we require to have larger collections of facts. Independently of this, however, it appears to me that from a philosophical point of view it is extremely probable that all theories of evolution as at present applied to life, are fundamentally defective in being too partial in their character; and perhaps I cannot better group the remainder of the facts to which I wish to refer than by using them to illustrate this feature of most of our larger attempts at generalization on this subject.

First, then, these hypotheses are too partial, in their tendency to refer numerous and complex phenomena to one cause, or to a

few causes only, when all trustworthy analogy would indicate that they must result from many concurrent forces and determinations of force. We have all no doubt read those ingenious, not to say amusing, speculations in which some entomologists and botanists have indulged with reference to the mutual relations of flowers and haustellate insects. Geologically the facts oblige us to begin with Cryptogamous plants and mandibulate insects, and out of the desire of insects for non-existent honey, and the adaptations of plants to the requirements of non-existent suctorial apparatus, we have to evolve the marvellous complexity of floral form and coloring, and the exquisitely delicate apparatus of the mouths of haustellate insects. Now when it is borne in mind that this theory implies a mental confusion on our part precisely similar to that which in the department of mechanics actuates the seekers for perpetual motion, that we have not the smallest tittle of evidence that the changes required have actually occurred in any one case, and that the thousands of other structures and relations of the plant and the insect have to be worked out by a series of concurrent evolutions so complex and absolutely incalculable in the aggregate, that the cycles and epicycles of the Ptolemaic astronomy were child's play in comparison, we need not wonder that the common sense of mankind revolts against such fancies, and that we are accused of attempting to construct the universe by methods that would baffle Omnipotence itself, because they are simply absurd. In this aspect of them indeed such speculations are necessarily futile, because no mind can grasp all the complexities of even any one case, and it is useless to follow out an imaginary line of development which unexplained facts must contradict at every step. This is also no doubt the reason why all recent attempts at constructing "Phylogenies" are so changeable, and why no two experts can agree about almost any of them.

A second aspect in which such speculations are too partial, is in the unwarranted use which they make of analogy. It is not unusual to find such analogies as that between the embryonic development of the individual animal and the succession of animals in geological time placed on a level with that reasoning from analogy by which geologists apply modern causes to explain geological formations. No claim could be more unfounded. When the geologist studies ancient limestones built up of the remains of corals, and then applies the phenomena of modern coral reefs to explain

their origin, he brings the latter to bear on the former by an analogy which includes not merely the apparent results but the causes at work, and the conditions of their action, and it is on this that the validity of his comparison depends, in so far as it relates to similarity of mode of formation. But when we compare the development of an animal from an embryo cell with the progress of animals in time, though we have a curious analogy as to the steps of the process, the conditions and causes at work are known to be altogether dissimilar, and therefore we have no evidence whatever as to identity of cause, and our reasoning becomes at once the most transparent of fallacies. Farther we have no right here to overlook the fact that the conditions of the embryo are determined by those of a previous adult, and that no sooner does this hereditary potentiality produce a new adult animal, than the terrible external agencies of the physical world, in presence of which all life exists, begin to tell on the organism, and after a struggle of longer or shorter duration it succumbs to death and its substance returns into inorganic nature, a law from which even the longer life of the species does not seem to exempt it. All this is so plain and manifest that it is extraordinary that evolutionists will continue to use such partial and imperfect arguments. Another illustration may be taken from that application of the doctrine of natural selection to explain the introduction of species in geological time, which is so elaborately discussed by Sir C. Lyell in the last edition of his "Principles of Geology." The great geologist evidently leans strongly to the theory, and claims for it the "highest degree of probability," yet he perceives that there is a serious gap in it; since no modern fact has ever proved the origin of a new species by modification. Such a gap, if it existed in those grand analogies by which we explain geological formations through modern causes, would be admitted to be fatal.

A third illustration of the partial character of these hypotheses may be taken from the use made of the theory deduced from modern physical discoveries, that life must be merely a product of the continuous operation of physical laws. The assumption, for it is nothing more, that the phenomena of life are produced merely by some arrangement of physical forces, even if it be admitted to be true, gives only a partial explanation of the possible origin of life. It does not account for the fact that life as a force or combination of forces is set in antagonism to all other forces. It

does not account for the marvellous connection of life with organization. It does not account for the determination and arrangement of forces implied in life. A very simple illustration may make this plain. If the problem to be solved were the origin of the mariner's compass, one might assert that it is wholly a physical arrangement both as to matter and force. Another might assert that it involves mind and intelligence in addition. In some sense both would be right. The properties of magnetic force and of iron or steel are purely physical, and it might even be within the bounds of possibility that somewhere in the universe a mass of natural loadstone may have been so balanced as to swing in harmony with the earth's magnetism. Yet we would surely be regarded as very credulous if we could be induced to believe that the mariner's compass has originated in that way. This argument applies with a thousand fold greater force to the origin of life, which involves even in its simplest forms so many more adjustments of force and so much more complex machinery.

Fourthly, these hypotheses are partial, inasmuch as they fail to account for the vastly varied and correlated interdependencies of natural things and forces, and for the unity of plan which pervades the whole. These can be explained only by taking into the account another element from without. Even when it professes to admit the existence of a God, the evolutionist reasoning of our day contents itself altogether with the physical or visible universe, and leaves entirely out of sight the power of the unseen and spiritual, as if this were something with which science has nothing to do, but which belongs only to imagination or sentiment. So much has this been the case, that when recently a few physicists and naturalists have turned to this aspect of the case, they have seemed to be teaching new and startling truths, though only reviving some of the oldest and most permanent ideas of our race. From the dawn of human thought, it has been the conclusion alike of philosophers, theologians and the common sense of mankind, that the seen can be explained only by reference to the unseen, and that any merely physical theory of the world is necessarily partial. This, too, is the position of our sacred Scriptures, and is broadly stated in their opening verse, and indeed it lies alike at the basis of all true religion and all sound philosophy, for it must necessarily be that "the things that are seen are temporal, the things that are unseen, eternal." With reference to the primal

aggregation of energy in the visible universe, with reference to the introduction of life, with reference to the soul of man, with reference to the heavenly gifts of genius and prophecy, with reference to the introduction of the Saviour himself into the world, and with reference to the spiritual gifts and graces of God's people, all these spring not from sporadic acts of intervention, but from the continuous action of God and the unseen world, and this we must never forget is the true ideal of creation in Scripture and in sound theology. Only in such exceptional and little influential philosophies as that of Democritus, and in the speculations of a few men carried off their balance by the brilliant physical discoveries of our age, has this necessarily partial and imperfect view been adopted. Never indeed was its imperfection more clear than in the light of modern science.

Geology, by tracing back all present things to their origin, was the first science to establish on a basis of observed facts the necessity of a beginning and end of the world. But even physical science now teaches us that the visible universe is a vast machine for the dissipation of energy; that the processes going on in it must have had a beginning in time, and that all things tend to a final and helpless equilibrium. This necessity implies an unseen power, an invisible universe, in which the visible universe must have originated and to which its energy is ever returning. The hiatus between the seen and the unseen may be bridged over by the conceptions of atomic vortices of force, and by the universal and continuous ether; but whether or not, it has become clear that the conception of the unseen as existing has become necessary to our belief in the possible existence of the physical universe itself, even without taking life into the account.

It is in the domain of life, however, that this necessity becomes most apparent; and it is in the plant that we first clearly perceive a visible testimony to that unseen which is the counterpart of the seen. Life in the plant opposes the outward rush of force in our system, arrests a part of it on its way, fixes it as potential energy, and thus, forming a mere eddy, so to speak, in the process of dissipation of energy, it accumulates that on which animal life and man himself may subsist, and assert for a time supremacy over the seen and temporal on behalf of the unseen and eternal. I say, for a time, because life is, in the visible universe, as at present constituted, but a temporary exception, introduced from that un-

seen world where it is no longer the exception but the eternal rule. In a still higher sense then than that in which matter and force testify to a Creator, organization and life, whether in the plant, the animal or man, bear the same testimony, and exist as outposts put forth in the succession of ages from that higher heaven that surrounds the visible universe. In them, too, Almighty power is no doubt conditioned or limited by law, yet they bear more distinctly upon them the impress of their Maker, and, while all explanations of the physical universe which refuse to recognize its spiritual and unseen origin, must necessarily be partial and in the end incomprehensible, this destiny falls more quickly and surely on the attempt to account for life and its succession on merely materialistic principles.

Here, again, however I must remind you that creation, as maintained against such materialistic evolution, whether by theology, philosophy or Holy Scripture, is necessarily a continuous, nay, an eternal influence, not an intervention of disconnected acts. It is the true continuity, which includes and binds together all other continuity.

It is here that natural science meets with theology, not as an antagonist, but as a friend and ally in its time of greatest need; and I must here record my belief that neither men of science nor theologians have a right to separate what God in Holy Scripture has joined together, or to build up a wall between nature and reigion, and write upon it "no thoroughfare." The science that does this must be impotent to explain nature and without hold on the higher sentiments of man. The theology that does this must sink into mere superstition.

In conclusion, can we formulate a few of the general laws, or perhaps I had better call them the general conclusions respecting life, in which all Palæontologists may agree. Perhaps it is not possible to do this at present satisfactorily, but the attempt may do no harm. We may, then, I think, make the following affirmations:—

1. The existence of life and organization on the earth is not eternal, or even coeval with the beginning of the physical universe, but may possibly date from Laurentian or immediately pre-Laurentian times.

2. The introduction of new species of animals and plants has been a continuous process, not necessarily in the sense of deriva-

tion of one species from another, but in the higher sense of the continued operation of the cause or causes which introduced life at first. This, as already stated, I take to be the true theological or Scriptural as well as scientific idea of what we ordinarily and somewhat loosely term creation.

3. Though thus continuous, the process has not been uniform; but periods of rapid production of species have alternated with others in which many disappeared and few were introduced. This may have been an effect of physical cycles reacting on the progress of life.

4. Species like individuals have greater energy and vitality in their younger stages, and rapidly assume all their varietal forms, and extend themselves as widely as external circumstances will permit. Like individuals also, they have their periods of old age and decay, though the life of some species has been of enormous duration in comparison with that of others; the difference appearing to be connected with degrees of adaptation to different conditions of life.

5. Many allied species, constituting groups of animals and plants, have made their appearance at once in various parts of the earth, and these groups have obeyed the same laws with the individual and the species in culminating rapidly, and then slowly diminishing, though a large group once introduced has rarely disappeared altogether.

6. Groups of species, as genera and orders, do not usually begin with their highest or lowest forms, but with intermediate and generalized types, and they show a capacity for both elevation and degradation in their subsequent history.

7. The history of life presents a progress from the lower to the higher, and from the simpler to the more complex, and from the more generalized to the more specialized. In this progress new types are introduced and take the place of the older ones, which sink to a relatively subordinate place and become thus degraded. But the physical and organic changes have been so correlated and adjusted that life has not only always maintained its existence, but has been enabled to assume more complex forms, and that older forms have been made to prepare the way for newer, so that there has been on the whole a steady elevation culminating in man himself. Elevation and specialization have, however, been secured at the expense of vital energy and range of adaptation,

until the new element of a rational and inventive nature was introduced in the case of man.

9. In regard to the larger and more distinct types, we cannot find evidence that they have, in their introduction, been preceded by similar forms connecting them with previous groups; but there is reason to believe that many supposed representative species in successive formations are really only races or varieties.

10. In so far as we can trace their history, specific types are permanent in their characters from their introduction to their extinction, and their earlier varietal forms are similar to their later ones.

11. Palæontology furnishes no direct evidence, perhaps never can furnish any, as to the actual transformation of one species into another, or as to the actual circumstances of creation of a species, but the drift of its testimony is to show that species come in *per saltum*, rather than by any slow and gradual process.

12. The origin and history of life cannot, any more than the origin and determination of matter and force, be explained on purely material grounds, but involve the consideration of power referable to the unseen and spiritual world.

Different minds may state these principles in different ways, but I believe that in so far as palæontology is concerned, in substance they must hold good, at least as steps to higher truths. And now allow me to say that we should be thankful that it is given to us to deal with so great questions, and that in doing so, deep humility, earnest seeking for truth, patient collection of all facts, self-denying abstinence from hasty generalizations, forbearance and generous estimation with regard to our fellow-laborers, and reliance on that divine Spirit which has breathed into us our intelligent life, and is the source of all true wisdom, are the qualities which best become us. While thanking you for the honor which you have done me in inviting me to deliver this address, and in conveying to you the kindly regards and good wishes of all your fellow-workers in the Canadian Dominion, allow me to express the fervent hope that we all may be one in our patient and earnest search for the truth.

BIOGRAPHIES OF SOME WORMS.

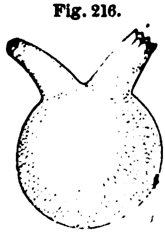
BY A. S. PACKARD, JR.

VIII. THE TUNICATA.

LIKE the Polyzoa and Brachiopods, the Ascidians may be said to be worms in disguise. The singular test easily confounded with the mantle of mollusks, the excurrent and incurrent orifices like those of the clam, led naturalists to regard them as low shell-less mollusks, but the structure of more important organs, and the mode of development of these animals, so unlike that of mollusks, has led some of our leading naturalists to decide that they should be placed among the worms.

One of the most important characters indicating the true affinities of the ascidians, is the pharynx, a sieve-like prolongation of the digestive canal, resembling that of Balanoglossus. The nervous system, like that of many low worms consists of a single ganglion, and not a chain of them surrounding the œsophagus as in the mollusks. In the tad-pole like Appendicularia, which resembles the larval ascidians, there is a chain of caudal ganglia from ten to eighteen in number, united by means of a nerve sent out from the ganglion in the head. Moreover the heart is a simple tube like that of some articulates. Besides the vermian characters there are some remarkable larval organs which suggest an affinity with Amphioxus and the lower vertebrates. It would thus seem that except in the more secondary external, superficial characters there is no good reason for the prevalent opinion that ascidians are mollusks.

Fig. 216.



Molgula.

At first sight the typical ascidians look like anything but worms. Fig. 216 (from Verrill's Report) represents *Molgula Manhattensis* of the natural size. It looks like a double-necked bottle when the two orifices are thrust out. The viscera are enclosed by a thick test or tunic, whence the name of the class, *Tunicata*. This test is rendered tough and dense by the presence of cellulose, a substance secreted usually by vegetable cells, and very rarely found in animals. There are two orifices, the most anterior corresponding to the

mouth, and the posterior leading into the anus. The alimentary canal is much bent on itself. The opening of the pharynx is surrounded by a fringe of tentacles, arising from the peritoneum or lining membrane next to the outer test. The capacious pharynx is perforated with slits, and serves as a respiratory cavity comparable with that of the worm, Balanoglossus. At the bottom of this respiratory sac opens the true mouth, which communicates by an œsophagus with the stomach, while the intestine is twisted so that the anus opens near but posterior to the mouth. There is a nervous ganglion on the dorsal side of the body situated at a point between the two external orifices, sending threads to the two openings in the test and the pharynx. The heart is a short tube open at both ends. Its action may be beautifully seen in the transparent Perophora of our coast. The current of blood is momentarily reversed, so that each end becomes, as Huxley remarks, "alternately arterial and venous."

Such in general terms is the structure of a typical simple ascidian as well as the compound ascidians, and the Pyrosoma and Salpa. The aberrant Appendicularia is, as has been observed, provided with a tail, and resembles the tailed young of the higher ascidians.

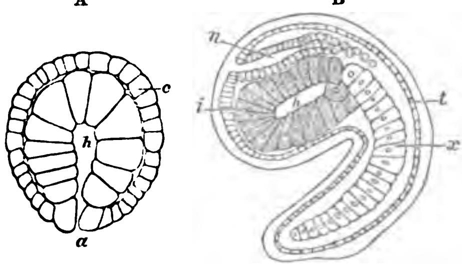
The ascidians are, for the most part, hermaphrodites, the ovary and testis being lodged in the same individual.

Development. While Milne-Edwards discovered that the larvæ of certain ascidians were tad-pole like, Kowalevsky, in 1866, studied the development of the ascidians and threw a flood of light on their history. The following account is an abstract of his classic memoir. The early stages of most ascidians is typified by the mode of growth of *Phallusia mamillata* Cuv., while the mode of growth from the free swimming larval period to the adult was traced in *Ascidia intestinalis*. Kowalevsky's discoveries were confirmed by Kupffer and others, while exceptional modes of development were pointed out by Lacaze-Duthiers and also Kupffer, who found that the larvæ of Molgula have no tail.

While some ascidians, such as Perophora, increase by budding, creeping by stolons along the fronds of sea-weeds, the common method of reproduction is by eggs and sperm cells. The eggs of Phallusia and the ascidians consist of a yolk, not protected by a yolk-skin, but surrounded by a layer of jelly containing yellow cells.

After fertilization by the sperm cells, which enter the substance of the egg tail foremost, the yolk undergoes total segmentation. The next step is the invagination of the ectoderm, a true Gastrula state resulting. Fig. 217, A (after Kowalevsky), represents the Gastrula; *h*, the primitive digestive cavity; *a*, the primitive opening, which soon closes; and *c*, the segmentation-cavity or primitive body-cavity. After this primitive opening (*a*) is lost to view, sometime before the embryo has reached the stage B, another cavity (*n*) appears with an external opening. This cavity is

Fig. 217.



Embryo Ascidian.

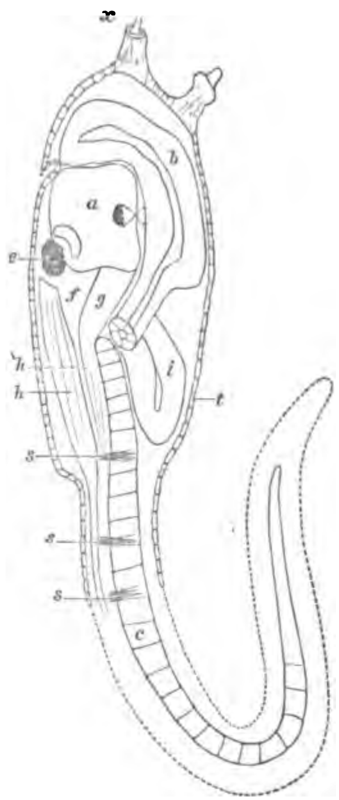
formed by a union of two ridges which grow out from the upper part of the germ. This is the central nervous system, and in the cavity are subsequently developed the sense-organs. We thus see, says Kowalevsky, a complete analogy in the mode of origin of the nervous system of the ascidians to that of the vertebrates, the nervous cavity, where the embryo is seen in section, being situated above the digestive cavity in both types of animals.

The next important stage is the formation of the tail. The pear-shaped germ elongates and contracts posteriorly until of the form indicated at Fig. 217, B (*i*, pharynx; *t*, epithelium forming the body-wall). At this period appears the axial string of nucleated cells, called the *chorda dorsalis*, as it is homologous with that organ in Amphioxus and the embryo of higher vertebrates. The nervous system consists of a mass of cells extending halfway into the tail and directly overlying the *chorda*, but extending far beyond the end of the latter as seen in the figure. The nerve-cavity (B, *n*) after closing up forms the nerve-vesicle, a large cavity (Fig. 218, *a*) in which the supposed auditory organ (*e*) and the supposed eye (*a*) arise; this cavity finally closes, and the sense-organs are indicated

by the small masses of pigment cells in the fully grown ascidian larva.

As the embryo matures, the first change observed in the cord is the appearance of small, highly refractive bodies between the cells. Between the neighboring cells soon appear in the middle minute highly refractive corpuscles which increase in size, and press the cell-contents out of the middle of the cord. After each reproductive corpuscle grows so that the central substance of the cell is forced out, it unites with the others, and then arises in the middle of the simple cellular cord a string of bodies of a firm gelatinous substance which forms the support of the tail. After this coalescence the substance develops farther and presses out the protoplasm of the cells entirely to the periphery. The cord when complete consists of a firm gelatinous substance surrounded by a cellular sheath which is formed of the remains of the cells originally comprising the rudimentary cord. The cells lying under the epithelial layer form a muscular sheath of which the cord (Fig. 218, c) is the support or skeleton.

Fig. 218.



Larval Ascidian.

The alimentary cavity arises from the primitive cavity (Fig. 217, A, h); whether the primitive opening (Fig. 217, A, a) is closed or not, Kowalevsky says is an interesting question. According to analogy with many other animals it probably closes. In Sagitta, Amphioxus, Phoronix, Limnæus, Echinus and others, we know that the opening which remains after the first invagination becomes the anus.

The larva hatches in from forty-eight to sixty hours after the

beginning of segmentation, and is then of the form indicated by Fig. 218 (copied with some additions and omissions from Kupffer's figure, being partly diagrammatic). This anatomist discovered in the larva of *Ascidia canina*, which is more transparent than Kowalevsky's Phallusia larva, not only a central nervous cord overlying the *chorda dorsalis* and extending well into the tail, while in the body of the larva it becomes broader, club-shaped and surrounds the sensitive cavity (*a*), but he also detected three pairs of spinal nerves (*s*) arising at regular intervals from the spinal cord (*h*, *h'*) and distributed to the muscles (not represented in the figure) of the tail; Kupffer calls *f* the middle and *g* the lower brain-ganglion. The pharynx (*b*), or respiratory sac, is now very large; it opens posteriorly into the stomach and intestine (*i*); *x* represents one of the three appendages by which the larva fastens itself to some object when about to change into the adult, sessile condition; *t* indicates the body-wall consisting of epithelial cells.

We will now, from the facts afforded us by Kowalevsky, trace the changes from the larval, free-swimming state to the sessile adult Ascidia, which may be observed on the New England coast in August. After the larva fastens itself by the three processes to some object, the *chorda dorsalis* breaks and bends, the cells forming the sheath surrounding the broken axial cord. The muscular fibres degenerate into round cells and fill the space between the chorda and the tegument, the jelly-like substance forming a series of wrinkles. With the contraction and disappearance of the tail begins that of the nerve-vesicle, and soon no cavity is left. The three processes disappear; the pharynx becomes quadrangular; and the stomach and intestine are developed, being bent under the intestine. A heap of cells arises on the anterior end beneath the digestive tract, from which originate the heart and pericardium. In a more advanced stage two gill-holes appear in the pharynx, and subsequently two more slits, and at about this time the ovary and testis appear at the bottom, beyond the bend of the alimentary canal. The free cells in the body-cavity are transformed into blood cells, and indeed the greater part of those which composed the nervous system of the larva are transformed into blood corpuscles. Of the embryonal nervous system there remains a very small ganglion, no new one being formed. The

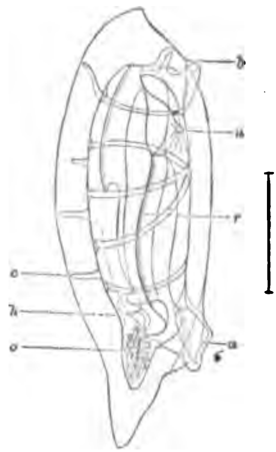
adult ascidian form meanwhile has been attained and the very small individuals differ for the most part only in size from those which are full-sized and mature.

It will be seen that some highly important features, recalling vertebrate characteristics, have occurred at different periods in the life of the embryo ascidian. Kowalevsky remarks that "the first indication of the germ, the direct passage of the segmentation cells into the cells of the embryo, the formation of the segmentation cavity, the conversion of this cavity into the body cavity, and the formation of the digestive cavity through invagination — these are all occurrences which are common to many animals and have been observed in Amphioxus, Sagitta, Phoronis, Echinus, etc. The first point of difference from other animals in the development of all vertebrates is seen in the formation of the dorsal ridges and their closing to form a nerve-canal. This mode of formation of the nervous system is characteristic of the vertebrates alone, except the Ascidians. Another primary character allying the Ascidians to the vertebrates, is the presence of a *chorda dorsalis*, first seen in the adult Appendicularia by J. Müller. This organ is regarded by Kowalevsky to be functionally, as well as genetically, identical with that of Amphioxus. This was a startling conclusion, and stimulated Professor Kupffer of Kiel to study the embryology of the ascidians anew. He did so, and the results this careful observer obtained, led him to fully endorse the conclusions reached by Kowalevsky, particularly those regarding the unexpected relations of the ascidians to the vertebrates, and it would appear from the facts set forth by these eminent observers, as well as Metschnikoff, Ganin, Ussow and others, that the vertebrates have probably descended from some type of worm resembling larval ascidians more perhaps than any other vermian type, though it is to be remembered that certain tailed larval Distomæ appear to possess an organ resembling a *chorda dorsalis*, and farther investigation on other types of worms may lead to discoveries throwing more light on this intricate subject of the ancestry of the vertebrates. At any rate, it is among the lower worms, if anywhere, that we are to look for the ancestors of the vertebrates, as the Cœlenterates, Echinoderms, the Mollusks, Crustacea and Insects, are too circumscribed and specialized groups to afford any but characters of analogy rather than affinity.

For example, the cuttle fish, with its "bone" and highly developed eye, is far more remote from the lowest fish, Amphioxus, than the Appendicularia or larval Ascidia.

Not all Ascidians have tailed larvæ; three species of Molgula have been found to have no tailed young and to attain maturity by direct growth. The young have five temporary, long, slender processes. Now as in other types of animals, as we have already seen, some forms have a metamorphosis and others attain the adult condition by direct growth. Professor Kupffer tells us that in *Ascidia ampulloides*, as observed by Van Beneden, the young has a tail, a *chorda dorsalis* and pigment spots, which are wanting in the young of several species of Molgula, but it has the five long, deciduous appendages observed in young Molgulæ. Among the compound Ascidians, Botryllus and Botrylloides have tailed young, while in other forms there is no metamorphosis.

Fig. 219.



Salpa Cabotii Des.

Besides the normal mode of reproduction, from eggs, it was discovered by Chamisso, in 1819, that the singular Salpa reproduced by budding; that in other words there was an alternation of generations, there being a sexual, solitary individual which gives rise by budding to chains, or aggregations of simple individuals, which reproduce by eggs. The startling announcement of the poet-naturalist, "that a Salpa mother is not like its daughter or its own mother, but resembles its sister, its granddaughter and its grandmother," was combated at first, but stated to be true by Sars, Krohn and others.

Our *Salpa Cabotii*[1] can be found in great numbers floating on the surface of the ocean on the southern coast of New England, and any one can study the solitary and social, or aggregated individuals, and satisfy himself of the truth of Chamisso's discovery.

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[1] Fig. 219. An individual from a mature chain, three-quarters view enlarged; *a* posterior or anal opening; *b*, anterior or branchial opening; *c*, processes by which the individuals of the chain were united; *h*, heart; *n*, nervous ganglion; *o*, nucleus; *r*, gill. After A. Agassiz, from Verrill's Report.

The Tunicates undergo, then, the following changes:

1. Morula state, or total segmentation of the yolk.
2. Gastrula.
3. Free-swimming tailed larva (or as in Molgula, no metamorphosis).
4. Adult, reproducing sometimes by budding (Parthenogenesis).

LITERATURE.

Chamisso. De Animalibus quibusdam e classe Vermium, etc. Berlin, 1819.

Milne-Edwards. Observations sur les Ascidies composées des Côtes de la Manche. Paris, 1841.

Kowalevsky. Entwickelungsgeschichte der einfachen Ascidien. (Mem. Acad. St. Petersburg. X. No. 15. 1866).

Kupffer. Die Stammverwandtschaft zwischen Ascidien und Wirbelthieren. (Schultze's Archiv für micr. Anat., vi, 1870).

——. Zur Entwickelung der einfachen Ascidien. (Schultze's Archiv. viii, 1872).

Consult also papers by Sars, Krohn, Huxley, Leuckart, Vogt, Lacaze-Duthiers and Ussow.

IX. GEPHYREA (Sipunculus).

There are two points of interest connected with these singular worms, *i. e.*, the fact that they were formerly associated with the Holothurians, and that their free-swimming Actinotrocha larva so closely resembles the young Echinoderms. The Sipunculus usually lives in broken shells, building out the mouth with a tube of sand; the anus is situated near the mouth, while in Priapulus it is situated at the end of the body. In none of these worms are there bristles, or indications of segments, and they in their general appearance with their tentaculated mouth, resemble certain Holothurians, as Synapta. Most of these worms are bisexual, Sipunculus however, or at least certain species of the genus, being hermaphroditic.

Whether the Gephyrea should be regarded as a separate division equivalent to the Annulata or as a subdivision of the latter, is a matter of uncertainty.

Development. The free-swimming larva of Sipunculus was first discovered and named "Actinotrocha" by J. Müller. It is related closely in form to Echinoderm larvæ, as well as to the Pilidium and other larvæ of the Nemertian worms. The fully grown larva is much like the larval Nemertian noticed on p. 365, fig. 171, the disposition of the digestive canal being the same, while on the head is a large umbrella-like expansion, and behind the mouth and on the end of the body is a ciliated band and twelve arm-like

projections, like those in certain Echinoderm larvæ. In all respects the Actinotrocha is a true *Cephalula*.

We will now, with Metschnikoff, follow the life-history of the Actinotrocha. The earliest stage he observed was when the larva had a transparent, ciliated body, with an umbrella-like expansion on the head, covering the mouth region, while the end of the body was truncated. The young at this stage was much like a Phoronis larva. Soon four projections arise at the end of the body, and twelve long, arm-like projections grow out by the time the larva becomes mature.

When the larva is about to transform into the Sipunculus, the end of the intestine bends up, opening outwards near the mouth. The umbrella is gradually withdrawn into the mouth, so that finally only a crown of short tooth-like projections surrounds the mouth. Finally the whole umbrella disappears in the œsophagus, is actually swallowed, while the arms on the end of the body are absorbed and disappear, and the end of the intestine projects far out from the body behind the mouth. By this time the Sipunculus form is clearly indicated, the body being long and slender and the mouth surrounded by a crown of short tentacles, and the anal opening is withdrawn within the head. The change from the free-swimming larva to the sedentary worm is effected in a very short time.

The Sipunculus, then, so far as its history is known, passes through a Cephalula stage before transforming into the adult worm.

LITERATURE.

Müller. Archiv für Anatomie, p. 103, 1846.

Metschnikoff. Ueber die Metamorphose einiger Seethiere. (Siebold und Kölliker's Zeitschrift, p. 244, 1871.)

Consult also papers by Wagener, Krohn, Schneider, Kowalevsky and Claparède.

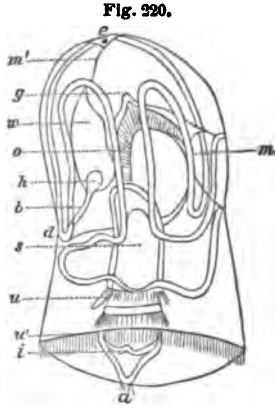
X. ANNULATA.

The life-history of Balanoglossus, a peculiar worm found in fine sand along our whole coast from Cape Ann to Beaufort, North Carolina, is one of singular interest. Its free swimming larva was regarded by Müller, who discovered and called it *Tornaria*, as the young of some starfish. Later studies by eminent naturalists only seemed to confirm this opinion, until in 1869 Metschnikoff suggested that it might be the larva of the worm, first described under the name of Balanoglossus, or whale's tongue, by Delle

Chiaji, and Mr. A. Agassiz fully confirmed the suggestion, giving an account of the intermediate stages between the larval and adult condition.

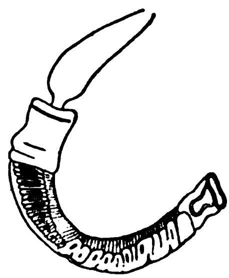
The *Tornaria* (Fig. 220[a] after A. Agassiz) seems in many respects like some echinoderm larvæ, differing from any yet known, however, in having an organ, the so-called heart (*h*) situated at the base of the canal leading from the water system to the dorsal pore. The water system is very fully developed. Mr. Agassiz says that the natural position of Tornaria in the water while moving, is usually with the eye-specks uppermost. "They revolve quite rapidly upon their longitudinal axis, and at the same time,

Fig. 220.



Tornaria, or young Balanoglossus.

Fig. 221.



Balanoglossus (immature).

inclining this axis, advance by a motion of translation, or revolve upon either of the extremities as a fulcrum. Previous to the transformation of Tornaria it is quite transparent; the brilliant carmine, violet or yellow pigment-spots are closely crowded along the broad belt of anal vibratile cilia, as well as smaller spots on the longitudinal bands of smaller cilia. The eye-specks are black and extremely prominent. The large and powerful cilia of the broad anal belt move comparatively slowly, more like the cilia of the embryo of mollusks, as has already been observed by Müller."

The Tornaria soon throws off its disguise of a young Echinoderm, and now begins its strange transformations. Previous to

[a] *a*, anus; *b*, branch of water system leading to dorsal pore, *d*; *e*, eyespeck; *g*, gills; *h*, heart; *i*, intestine; *m*, mouth; *m'*, muscular band from eye to water tube; *o*, œsophagus; *s*, stomach or alimentary canal; *u*, lappet of stomach; *u'*, anal band of cilia; *w*, water system.

any other change two gills develop from the round bag-shaped diverticula of the œsophagus, and afterwards three more pairs of gill-slits arise, somewhat as in the young Ascidian. Agassiz then remarks that the "passage of Tornaria with the young Balanoglossus is very sudden, taking place in a few hours; but unlike the transition from the Pluteus into the Echinoderm, there is no resorbition of any portion of the larva." The body lengthens, the proboscis is indicated and assumes much of the form of the adult, the four pairs of gills are well developed, the cilia drop off first, the longitudinal bands and finally the transverse ones, and then the collar becomes well marked. The young worm, for it rapidly assumes the adult Balanoglossus likeness, though much shorter proportionally, now instead of swimming "creeps rapidly over the bottom by means of its proboscis, which acts as a sort of propeller taking in water at the minute opening of the anterior extremity of the proboscis, and expelling it through an opening on its ventral side immediately in front of the mouth."

Fig. 221, after Agassiz, represents the youngest stage found in the sand, but it differs from the adult simply in the shorter body and less distinct development of the collar, with fewer gills and other unimportant points of difference.

There is considerable difference of opinion regarding the affinities of this worm. On first digging it out of the sand at Beaufort, N. C., it seemed to us a most anomalous form, the large soft proboscis, the singular gills, and the absence of setiform feet, apparently forbidding its relationship to the true Annelides. Yet its true position appears to be between the leeches and setiferous Annelides, with some Nemertian analogies. The reader can choose between the opinion of Gegenbaur that this worm is the type of an order equivalent to the Annelides, or a true Annelid allied to the Terebrellidæ, Clymenidæ and allied Annelides, as suggested by Metschnikoff and Kowalevsky; or that of A. Agassiz who regards it as the type of a family intermediate between tubicolous Annelides and Nemertians."

Turning now to the lowest Annulata, the leeches, in which there are no bristles or gills, while each end of the body terminates in a sucker, it has been found by Rathke and Kowalevsky that their embryology is nearly identical with that of the earthworm, in which there are bristles. In the leeches the sexes are united in the same individual, except in the genus Malacobdella. The eggs

after fertilization undergo total segmentation. There is a primitive band much as in insects, and the adult form is attained before the animal is hatched. There is no metamorphosis. So with the earthworms. Kowalevsky studied the mode of development of two species. As nothing has heretofore been known of the life-history of so common a creature we will delay a moment to learn the results of the Russian naturalist's observation. The eggs of the European *Lumbricus agricola* were laid while the worm was in confinement in January and February. They were laid in numerous capsules, sometimes as many as fifty eggs in a capsule, though usually only three or four embryos were found in a capsule. The egg-capsules of *Lumbricus rubellus* were found in dung. They were much smaller and contained but one egg.

Segmentation is total, and after the embryo-cells are arranged in two layers, the innermost layer (endoderm), invaginates and forms a primitive cavity. The embryo at this time seems, then, not to correspond to the gastrula condition of other worms, although as in other worms, the Ascidians, Insects and Vertebrates, there are two primitive germ-lamellæ. Later in embryonic life, a primitive band like that of insects (which will be described farther on), rests on the outside of the yolk, as in the leach (*Hirudo medicinalis*). Finally, the form of the earthworm is attained before it breaks through the egg-shell, and it hatches without undergoing a metamorphosis, in a condition differing but slightly from that of the adult worm so familiar to us, the body being proportionately shorter and thicker near the middle.

We now come to the sea worms, or Annelides, in which there are external gills and often a complicated locomotive apparatus, consisting of fleshy oar-like projections from the body, and strong bristles. They have free-swimming larvæ, which by a complicated metamorphosis, comparable with that of the Nemertian worms, attain the adult worm-condition.

A singular type is Phoronis, which lives in a membranous tube attached to rocks, and recalls strikingly the appearance of a Polyzoan, as it has a true lophophore and the intestine opens externally near the mouth. It is in fact a connecting link between the Annelides and the Polyzoa. Its life-history as told by Metschnikoff is nearly identical with that of Sipunculus.

We will now in a fragmentary way study the mode of development of certain typical Annelides, beginning with the lower forms.

The common *Spirorbis spirillum* (Gould) whose minute nautilus-like shells cluster on the common Fucus of our coast, lays its eggs

Fig. 222.

Egg of Spirorbis.

Fig. 223.

Larva of Spirorbis.

Fig. 224.

Older larva of Spirorbis.

in strings formed of two rows (Fig. 222, after A. Agassiz), and laid on the sides of the body within the shell. The young ciliated embryos may be seen in the eggs, the eye-spots being very distinct. Fig. 223 (this and Figs. 224, 225, after A. Agassiz), represents the embryo just after hatching. It will be seen that it is already far advanced before leaving the egg, and Agassiz thinks that the free-swimming life of the larva does not last more than from eight to ten hours, as "it frequently happens during a night that the smooth sides of the vessel are completely covered with small limestone tubes, formed by the young Spirorbis hatched the evening before." Fig. 223 represents the young Spirorbis soon after its escape from the egg,

Fig. 225.

Young Spirorbis.

having only one tentacle (*t*) developed on the right side. In a succeeding stage (Fig. 224) the opercular tentacle (*to*) which is destined to act as a door to the hole of the cell, begins to grow out, and there are two pairs of bristles. Shortly after this the young Spirorbis hatches, and before building its limestone tube assumes the form indicated by Fig. 225, in which there "are nine rings," with tentacles nearly as branching as those of the adult, and a well formed operculum which with advancing age loses all trace of its former tentacular nature." The subsequent changes are very slight.

The metamorphoses of the other sea worms are well marked, and the larval forms present a great variety of shapes. As a rule, perhaps, the eggs undergo total segmentation, and the embryo leaves the egg in the Cephalula condition, the head-end being large and full, with the alimentary canal more or less flexed. In some cases, as in *Terebrellides Stroemii* Sars, observed by Willemoes-Suhm, the young leaves the egg as a Trochosphere, ("Atrocha" of Claparède and Metschnikoff, who observed the same stage in Lumbriconereis ?) like that of certain mollusks and the Polyzoa, being spherical, with a long, cephalic tuft of cilia, two eye-spots, and a zone of cilia, but without any bristles. Others, as in Leucodora, are similar, but provided with a few long setæ, which act as oars.

Fig. 226.

Young Polydora.

The early stages of the embryo have not yet been studied, so that we are not in possession of any certain knowledge regarding the development of the embryonal membranes and the presence or absence of a gastrula condition.

Soon after the larva leaves the egg, branches of bristles appear and the body is divided into segments. Fig. 226 (this and Figs. 227, 228, 229, 230, 231, after A. Agassiz), represents an advanced larva of Polydora. Fig. 227 and 228, illustrate the early stages of Nerine.

The early stages of *Phyllodoce maculata* are indicated by figures 229, 230, 231. The subsequent changes are not important, consisting chiefly of the addition of a great number of segments and

the growth of smaller bristles. How the adult forms appear may be known by a glance at the accompanying figures of certain sea worms of our coast described and figured by Prof. Verrill, from

Fig. 227.

Young Nerine.

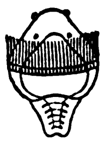
Fig. 228.

Older Nerine.

whose reports the figures are taken. Fig. 232, represents *Clymenella torquata*, 233, *Euchone elegans*, and fig. 234, a not uncommon and very elegant worm, *Cirratulus grandis*.

Besides the normal mode of reproduction by eggs, certain

Fig. 229.



Young Phyllodoce.

Fig. 230.

Side view of Fig. 229.

Fig. 231.

Advanced young of Phyllodoce.

worms reproduce by self-division or budding; such are Nais, Sabella, Filograna, Protula, Syllis, Autolytus, and others. In the latter worm as well as in Syllis there is, according to A. Agassiz,

an alternation of generations, an asexual form giving rise to male and females, while these sexual and asexual forms are so unlike each other as to pass for different species and even genera.

The Annulata, then, to sum up what is known of their life-

Fig. 232.

Clymenella torquata.

Fig. 233.

Euchone elegans.

history, besides reproducing by budding and parthenogenetically, usually lay eggs, and pass through the following stages:

1. Morula state.
?2. Gastrula (not observed).
3. Atrocha or Trochosphere.
4. Cephalula.
5. Adult.

LITERATURE.

Milne-Edwards. Observations sur le Dévelopment des Annélides. (Ann. Sc. Nat. III, 145, 1845).

Sars. Zur Entwickelung der Anneliden (Archiv für Naturg. T. i, 11, 1845).

Busch. Beobachtungen ueber Anat. und Entwickelung einiger Wirbelloser Thiere. Berlin, 1851.

Rathke. Beiträge zur Entwicklungsgeschichte der Hirudineen. Leipzig, 1862.

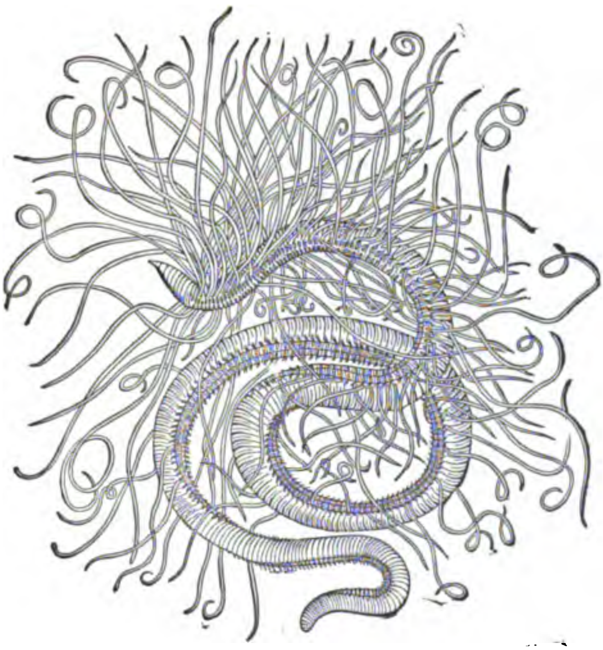
A. Agassiz. On alternate Generations in Annelides. (Jour. Bost. Soc., N. H. vii, 1862.)

Claparède. Beobachtungen ueber Anat. und Entwicklungsgeschichte Wirbelloser Thiere, etc. Leipzig. 1863.

——— *and Metschnikoff.* Beiträge zur Kenntniss der Entwickelungsgeschichte der Chætopoden. (Siebold and Kölliker's Zeitschrift, 1868).

Compare also the writings of Lovén, A. Agassiz and Kowalevsky, already cited, and papers by Krohn, Leuckart and Pagenstecher, Frey and Leuckart, Schultze, J. and Max. Müller, Busch and Willemoes-Suhm.

Fig. 234.



Cirratulus grandis.

REVIEWS AND BOOK NOTICES.

A Late Paper on Birds.[1] — Mr. William Brewster's recent visit to West Virginia results in a series of notes on a hundred species of birds, one-fifth of which are *Sylvicolidæ*, and one-eighth *Fringillidæ*. The observations were made from about the beginning to the height of the "season," and include some extended biographical sketches of certain species with which the New England ornithologist is less familiar than he is with some others, such having naturally attracted the writer's special attention. Thus we have good notices of such birds as the *Polioptila*, *Thryothorus ludovicianus*, *Helmitherus vermivorus*, *Dendrœca cœrulea*, *Seiurus ludovicianus*, *Oporornis formosus*, *Icteria virens*, *Myiodioctes nictratus*, *Cardinalis*, etc. The writer dwells upon the song, bringing to this matter an appreciative ear; and indeed it may be said that the whole paper is marked by results of unusually close and well-directed observation, showing the author's trained capacity for good sound field work. The list takes, without question, a fair place in our faunal series, and very acceptably complements the previous one written by Mr. Scott,[2] from a locality close at hand.

The "Annals of the Lyceum," in which this paper appears, are "looking up" in ornithology, at least so far as number of authors are concerned, and promise to become a more favorite medium of publication than they have hitherto been. In saying this, we do not overlook Mr. Lawrence's widely known and fully appreciated series, of fifty or sixty papers, which for many years has given the "Annals" their chief ornithological weight, as Mr. Cassin's did the Philadelphia "Proceedings." The prompt appearance of the signatures of late, and the admirable typographical execution of the Salem Press, are strong points in favor of the "Annals." The present paper appears to have been carefully read in the proof, and the more we see of scientific printing, the more we are satisfied that care bestowed upon details of typography is pains well taken. Comeliness of appearance is well worth a thought; and

[1] Some Observations on the Birds of Ritchie County, West Virginia. <Ann. Lyc. Nat. Hist., N. Y., xi, 1875, pp. 129-146.

[2] Partial List of the Summer Birds of Kanawha County .... <Proc. Bost. Soc. Nat. Hist. xv, pp. 219, *et seq.*

attention to the shape of names tends to this result. The specific name of the house-wren is *aëdon* not *œdon;* the generic name of the wood-warblers is *Dendrœca*, not *Dendroica*. Occasional airing of the Greek roots is as good for the health of the outgrowing words, as stirring the soil about the roots of a tree is for its vigor. In writing *Mniotilla* instead of the customary *Mniotilta*, did Mr. Brewster intend to revert to the original Vieillotian spelling? For that is the way Vieillot spells the word, if we remember rightly, in the Ency. Meth. — E. C.

MORSE'S FIRST BOOK OF ZOOLOGY.[1] — This charming little book will, we imagine, be immensely liked by young people, whether they use it as a text-book or receive it as a holiday present. It is designed for boys and girls, and presupposes an entire ignorance of animals on the part of the student. The plan is to teach by a study of the objects themselves. The writer tells young people how and where to look for specimens. After an excursion in search of shells, insects, etc., the author as it were, sits down by the reader with his or her hands full of the different objects, and draws their attention to the difference between them, and to the main points in their structure. There is little method in the plan of the book, and the reader is not bewildered with a "natural system" before he has learned something about the animals composing it.

The drawings are with few exceptions original, while all have been engraved expressly for the book. They add much to the attractiveness of the text. The illustrations of the parts of insects, the mode of growth of shells, and the anatomy of vertebrates, are strikingly original. The chapter on vertebrates presents matter that we think will be new to many teachers of comparative anatomy. The book is sumptuously printed and bound.

BOTANY.

SEQUOIA SEMPERVIRENS. — At a recent meeting of the California Academy of Sciences, Dr. A. W. Saxe made a preliminary report on a grove of colossal redwood trees that have been discovered on the course of the San Lorenzo, which takes its rise near Saratoga, in Santa Clara County, and debouches into the Bay of Monterey,

[1] First Book of Zoology. By Edward S. Morse, Ph.D. New York. D. Appleton & Co., 1875. 12mo. pp. 190, with 158 woodcuts. $1.25.

at Santa Cruz. The trees are in a forest around the head-waters of the stream. One of them eclipses all that have been discovered on the Pacific Coast. Its circumference as high as a man can reach, standing and passing a tape line around, is a few inches less than one hundred and fifty feet. This is beyond the measurement of any of the *Sequoias* (*gigantea*) in the Calaveras Grove. The height is estimated at one hundred and sixty feet, and a part of the top lying on the ground riven off by lightning, or a tornado, is over one hundred feet in length. The other trees in the vicinity are not as large, but all are of immense girth. Dr. Saxe promised to get information more in detail from the President of a flume company in that section.

This region has but recently been explored, and what other marvels of vegetation it contains, remains to be seen. The stumps of redwood trees of immense proportions, have been reported, from time to time, to the Academy, by explorers in the Mt. Diable range along the hills back of Oakland, but now we are likely to have further discoveries of these majestic conifers in all their glory, height, diameter and foliage.—R. E. C. S.

SULLIVANTIA OHIONIS, Torr. & Gray.—I have just been collecting a large quantity of this rare and beautiful little plant. It grows in great abundance about four miles from the college, in a dark, well-wooded ravine, known as "Clifty Ravine." It is found clinging to the damp limestone cliffs just above Clifty Falls, and is rapidly spreading down the ravine. It is a charming little plant and is invariably found with its roots buried in a bunch of damp moss, as if to prove to us that it belongs to Dr. Sullivant and loves what he did. In the description, as given in Gray's Manual, there is omitted one character which is always the first one to attract the attention, even of the casual observer. Upon showing fresh specimens to persons I have never failed to hear the exclamation, "what pretty *shiny* leaves!" And it is a fact, for there is always a beautiful gloss upon the leaves as if covered with a fine coat of varnish. Clifty Falls, Jefferson Co., Ind., must now be added to Highland Co., Ohio, and the Wisconsin river. —JOHN M. COULTER, *Hanover College*, *Hanover*, *Ind.*, *July* 21*st*.

PUCCINIA MALVACEARUM, has probably been for many years in the United States. Some thirty years ago I found the hollyhock in all old gardens where it used to self-sow, annually, and take

care of itself generally. A few years after I endeavored to introduce the improved "Cater" hollyhocks from England. They did remarkably well the first year, but the next were attacked by a small fungus which destroyed the leaves almost as fast as they appeared; and it was with difficulty they could be had to retain strength enough to flower at all. Finally, they were all destroyed before flowering, as were the common single ones in the gardens. Since the discovery in England that *Puccinia malvacearum* causes a disease like this, I have endeavored to find a specimen in order to identify the species, but I have failed, as the whole race of hollyhock about here seems to have disappeared.—THOMAS MEEHAN.

ZOOLOGY.

OPORORNIS FORMOSUS BREEDING IN EASTERN NEW YORK.—A few days ago, while out collecting with a friend, we were attracted by the alarm note of a bird, which he shot, and it proved to be a male of the Kentucky warbler. In passing out of the woods, which were overgrown with ferns and other perennials, we started a female from the ground, and after a careful search we found the nest, which was slightly elevated from the ground, composed of dry chestnut leaves and coarse grass, and lined with horse hair. The eggs, which were three in number, were white, thickly marked with small reddish-brown spots on the larger end. The nest was scarcely more than twenty feet from the public road. As I have not heard of its nest being found before in New York, I thought it might possibly be interesting to some of your readers. —A. K. FISHER, *Sing Sing, N. Y., June* 19, 1875.

THE PURPLE GALLINULE.—A fine specimen of the Purple Gallinule, was shot at "Henry's Pond," "South End" Rockport, Mass., on April 12th, by Mr. Robert Wendel.—G. P. WHITMAN.

CALOPTENUS SPRETUS IN MASSACHUSETTS.—Specimens not differing in any appreciable respect on comparison with Californian examples occurred in September at Amherst, Mass.—A. S. PACKARD, JR.

GEOLOGY.

INTERESTING FOSSILS FROM ILLINOIS.—At a recent meeting of the Academy of Natural Sciences of Philadelphia, Professor Cope

stated that he had recently received from Mr. John Collett, of the Geological Survey of Indiana, a number of vertebrate remains from some point in Illinois. The specimens were taken from a blackish shale and consist of separate vertebræ, and other parts of the skeleton, often in a fragmentary condition. Although the absence of information as to the mutual relations of the pieces renders the identification difficult, yet the interest attaching to them, in consequence of their peculiar forms and the locality of their discovery, renders it important to determine their zoological position. Mr. Collett informed Prof. Cope that all the specimens were found near together and at the same horizon.

A remarkable peculiarity of all the vertebræ of the series is a longitudinal perforation of the centrum, a character which exists in the living lizards of the genus Sphenodon of New Zealand. The bones of the limbs and scapular arches are so decidedly reptilian, and so unlike those of any Batrachia with which we are yet acquainted, that they probably belong to the former class. They constitute the first definite indication of the existence of reptiles of the order *Rhynchocephalia*, in the Western Hemisphere. They belong to two species of two new genera which were named respectively, *Cricotus heteroclitus* and *Clepsydrops Collettii.*

Associated with these saurians were found teeth of two species of fishes, which are important in the evidence of the position of the beds in which they occur. One of these is a new species of Ceratodus and the other a Diplodus. The former genus is characteristic of the Triassic period in Europe, one species having been found in the Oolite. It still lives in North Australia. In both these respects the lizards mentioned present a remarkable coincidence. They also belong to the horizon of the Trias in Europe, and the only living species is found in New Zealand. Thus it would seem that a fragment of this fauna, so ancient in the Northern Hemisphere and so remarkably preserved in the Southern, has been brought to light in Illinois. It must be added, in reference to the geologic age of the fossils, that the genus Diplodus has not yet been discovered above the carboniferous, and that one genus of the family of lizards described belongs to the Permian in Germany. It cannot therefore be determined at present whether the formation in which they occur is Triassic or Permian.

MICROSCOPY.

SPENCER MICROSCOPES.—Charles A. Spencer & Sons of Canastota, N. Y., announce the transfer of their enterprise to the Geneva Optical Co., of Geneva, N. Y., and state that almost unlimited facilities will enable them to supply customers with genuine Spencer workmanship with ordinary business promptness, a promise which will prove attractive to those who have learned by experience that microscope-work, on the average, can be more safely ordered as a legacy for one's heirs than with any reasonable expectation of its being received in time to be of any use to himself. Besides their usual forms of stand, and the more useful accessories, the Spencers announce two series of objectives,—a series of from 4 inch to $\frac{1}{75}$ inch focus, of extremely large angle and price to match, and a series of very judiciously chosen low angles at a very moderate price. The name of Spencer is connected, more radically than any other, with the development of the modern high-angled objective, and it is interesting, though of course not decisive, to know that the distinguished workers bearing this name, so far from having lost faith in the fact or the utility of extreme angles, continue to announce the almost incredible angles of 50° for the 1 inch, and 175° for nearly everything from the $\frac{1}{4}$ upwards. The acceptance of the term ocular in place of eye-piece is a notable contribution to an improved nomenclature.

MOUNTING STAINED LEAVES.—Mr. G. Pim exhibited, at the January meeting of the Dublin Microscopical Club, leaves mounted in Deane's Gelatine, which were so transparent that the tissues throughout could be readily examined by merely focussing down to the required level. They were bleached in a solution of chlorate of potash, one drachm to half an ounce each of water and nitric acid, and after washing stained with carmine solution.

COLORING MATTER OF "RED SNOW."—This minute vegetable organism, *Protococcus nivalis*, whose growing form is green, but whose bright red resting spores have given to it its familiar name, has been recently examined under the micro-spectroscope by Dr. J. G. Hunt, who states that its coloring matter leaves unchanged the red, orange and yellow portions of the spectrum, but entirely absorbs the violet portion.

NOTES.

THE meeting of the BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, held at Bristol during the last week in August, is pronounced a decided success in all of its many sections. Over 2200 persons belonging to the Association, consisting of members, associates and ladies, were present, and a very large number of papers were read, many of the sections holding until the last hour of the meeting. The arrangements of the committees having charge of the meeting, and the hospitality of the citizens of Bristol, are said to have been all that could be desired. The address of the President, Sir John Hawkshaw, is most instructive and interesting, and the addresses of the several gentlemen presiding over the sections are what would be expected of men so distinguished in their respective departments. We cannot do better than to advise our readers to peruse the very full reports of the addresses and more important papers given in "Nature," for Sept. 2, and following numbers.

The next meeting will be held in Glasgow, on Sept. 6, 1876, under the presidency of Sir Robert Christison.

AN OHIO STATE ARCHÆOLOGICAL CONVENTION, was organized at Mansfield, Ohio, on Sept. 1. We have only seen an account of the proceedings of the first day, and do not yet know what results were attained towards a permanent organization. About fifty delegates were present. Papers were read and discussed and specimens exhibited.

THE FRENCH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, held its meeting at Nantes, during the last of August, and was largely attended. Many papers were read in the several sections and the meeting was regarded as quite successful. Full reports are given in the "Revue Scientifique" for Aug. 28, and following weeks.

THE IOWA ACADEMY OF SCIENCES was organized in August last. Its headquarters will be at Iowa City. The present officers are:— *President*, Prof. Bessey, of Ames; *Vice President*, Dr. Middleton, of Davenport; *Secretary and Treasurer*, Prof. Preston, of Iowa City.

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ADDRESS

OF

PROF. H. A. NEWTON,*

VICE PRESIDENT FOR SECTION A.

MEMBERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE:

I THANK you heartily for the honor you have done me in calling me to preside over this section.

The first of the subjects named as belonging to section A, is mathematics. In the few words I shall say, I wish to ask for that branch the real primacy which has thus in form been given to it. I plead for more study of mathematics by American men of science.

I do not speak of its place in education. Whatever interest we may have in schemes of education, we are not discussing them here. That there has been, and is, a notable lack in the amount of American contributions to mathematics has been so fully shown by my predecessor in this office in a recent number of a leading review, that I need not repeat the story.

It is not, perhaps, to be wondered at that in a new country its flora and fauna, its physical and geological features, should have more attraction at first than the exact sciences. Then, too, there have been in this country large rewards to labor, especially to

*Before the American Association for the Advancement of Science, at Detroit, 1875.

skilled labor. Livings and prizes have enticed men to work where practical results are directly in view, in the applied rather than in the pure mathematics.

But whether these reasons or others have caused it, the unpleasant fact is that the American contributions to the science of quantity have not been large. Three or four volumes, a dozen memoirs, and here and there a fruitful idea having been selected from them, there is left very little that the world will care much to remember. I refer, of course, to additions to our knowledge, not to the orderly arrangement of it. To make first-rate text-books, or manuals, or treatises, is a work of no mean order, and I would not underestimate it. In good mathematical text-books we need not fear comparison with any nation. But so few additions have been made to our knowledge of quantity, that I fear that the idea has been quite general among us that the mathematics is a finished science, or at least a stationary one, and that it has few fertile fields inviting labor, and few untrodden regions to be explored. Hence many bright minds, capable of good work, have acted as though the arithmetic, the algebra, and the mechanics which they studied covered all that is known of the science. Instead of going on in some path out to the bounds of knowledge, as they had perhaps the ability to do, they dug in the beaten highways, and with care planted seed there, hoping for fruit. How much such ill-directed thought has been spent on the theory of numbers, on higher equations, on the theory of the tides, &c., which if rightly expended on some untrodden though humble field of the science, might have added really to human knowledge! And yet hardly any science can show on the whole a more steady progress, year by year, for the last fifty years, or a larger and healthier growth, than the science of quantity. Here too, as in every other science, the larger the field that has been acquired, the longer its boundary line from which laborers may work out into the region beyond.

An individual may wisely neglect one science, in order to work in another. But a nation may not. For the healthy growth of all, each science should be fostered in its due proportion. But the mathematics has such relations with other branches, that neglect of it must work in time wider injury, I believe, to the cause of science, than neglect of any other branch. I will give a few reasons for this belief.

First, I appeal to your experience. Am I wrong in supposing that

each of you has, at one time or another, been arrested by lack of sufficient knowledge of the mathematics in a line of research that seemed promising? Would not each of you join me in urging a young student in almost any branch of science to acquire first of all such a knowledge of geometry, analysis, and mechanics, that the main ideas in them shall ever be familiar to him, and their processes at need be easily recalled? Certainly so often has the regret of a want of such knowledge been expressed to me by successful men of science, that I have little doubt of your answer.

Again, I argue from a natural law of succession of the steps of discovery in the exact sciences. We first see differences in things apparently alike, or likeness in things apparently diverse, or we find a new mode of action, or some new relation supposed to be that of cause and effect, or we discover some other new fact or quality. We frame hypotheses, measure the quantities involved, and discuss by mathematics the relations of those quantities. The proof or disproof of the hypotheses, most frequently depends upon the agreement or discordance of the quantities. To discover the new facts and qualities has sometimes been thought to be higher work than to discuss quantities, and perhaps it is. But at least quantitative analysis follows qualitative. It is after we have learned *what kind* that we begin to ask *how much*. The investigator is lame if he is not prepared to follow up the discovered relations of the quantities.

Again, throughout the sciences of this section, the laws are more and more assuming a mathematical form. In physics I need hardly mention the increasing rule which rational mechanics is acquiring in reducing classes of phenomena to varieties of forces and motions. In chemistry, mathematical laws must govern the combinations of the elements, both in the processes and in the results of chemical union. Though we may not now explain chemical action as one branch of mechanics, yet the mathematical sciences of heat and light cannot be made complete without extending mathematics over large provinces in chemistry. Even in the sciences of section B, the mechanical and other quantitative ideas are gaining a sure place.

The unwisdom of neglecting the mathematics is again seen by considering some of the problems, which appear to be in their nature capable of a mathematical solution. To explain by the accepted laws of rational mechanics all the forces and motions of the

ultimate particles of matter, of inorganic matter even, may very well be beyond the powers of the human mind. But that some of those forces and motions will be explained, even at an early day, seems to be almost certain. So the essential differences in the chemical elements may not be beyond discovery and explanation. Each line in the spectrum has its definite place, and those places are the results of certain laws of structure of the substance that gives the spectrum, and of its consequent action upon the light that comes from or traverses the substance. The time seems near for a Kepler who shall formulate those laws, and for a Principia which shall unite them in their most general mathematical expression. In like manner along the line that in astronomy and physics separates the unknown from the known, there are hundreds of questions whose solution, if they are to be solved at all, must be in part mathematical.

It is with some hesitation that I leave the more familiar ground of this section and speak of the laws of quantity in the other sciences. But there is good reason apparent to even the outside observer, for the belief that the mathematics will in the future (of course, in some cases, the very distant future) have much to do in fields from which it is now very properly shut out. Indirectly, through physics, it has already a foothold in some of them.

Political economy is in its ultimate nature a branch of applied mathematics, and even in its present condition we are entitled to distrust the guidance in it of one who has not clear conceptions of the relations of quantity. In fact, most of the questions in social science seem to have a two-fold character, the one moral, and the other mathematical. In geology how many problems are rising into importance whose solution depends upon mathematics! The geometry of animal and vegetable forms is a subject as yet almost untouched by the mathematician. Yet in the nature of the case each form is the result of definite forces, and similarity and law in the forms represent like properties in the forces producing them.

There is, moreover, a large possible field of applied mathematics in the science that shall explain the relations between the facts of the outside world and the impressions which they make through the organs of sense on the mind. The Greeks solved practically one of its problems when they made the lines of the Parthenon curved that they might appear straight. Another is met by the astronomer when he has to apply to his own observations a personal

equation. When we can explain the correction which one color needs because of its nearness to another color, we may perhaps have more hope of applying to color a unit of measure, and so treating of its quantity. Music has its mathematical basis, and differences in sounds have submitted to analysis and measurement. The physiological theories of vision and hearing must, as they develop by experiment, furnish many problems to be solved by mathematics.

Even in the sciences beyond the domain of this Association there is some evidence of the sovereignty of number and measure. Some of those who have most thoroughly studied the theory of the beautiful, believe that mathematical laws will yet be found to lie at the basis of that theory. The recognition of a more and a less in all our mental powers, impressions, and actions; of a law of obedience to the strongest motive; of an inseparable connection of the greatest good with right moral action; what are these but the indications of the existence of quantitative laws in mental and moral sciences?

That there is a growing conviction that mathematical relations run through all subjects of thought is proved by the increasing use of the word *force*. Men speak of vital forces, mental forces, moral forces, social forces, force of will, force of passions, of affections, of appetites, force of words, force of public opinion, force of conscience, force of character, and so on, through all the range of thought. The word force can hardly be used, even as a metaphor, without implying, to some extent, the idea of a cause and an effect, each possessing the attribute of quantity, and each related quantitatively to the other, though we cannot in our present ignorance measure the one or the other.

Is all this a mere fancy, or a day-dream of the imagination, rather than a sober conception of science fitted to this occasion? If it so seems to you, look at the actual history of one kind of quantity, that of probability. Quantity of probability differs from most kinds of quantities, in that it is an impression on the mind that has no necessary correspondence with the facts of the outside world. It is, to use the mathematical term, a function of finite knowledge, depending for its magnitude entirely upon what we know, or think we know, changing with every accession of knowledge, real or supposed, becoming certainty in the presence of full knowledge, and having no existence where there is no knowledge at all.

This mental impression of the more and the less probable mathematicians learned to measure. Its theory was first applied to simple games of chance, but it has grown in these two hundred years until it is now the firm basis on which rest pecuniary contracts for many thousands of millions of dollars in insurance. It guides and controls, by the method of least squares, approximate measurements in all branches of exact knowledge, and going over into mental science requires logic to be rebuilt from the bottom.

Has the thought arisen in any of your minds that this idea of a possible extension of the science of quantity is derogatory to those other sciences over whose domains it may some time claim a qualified sovereignity—that it puts the good and the beautiful even alongside of the masses which we weigh and the bulks which we measure? Pure mathematics is not a science of matter. It is a mental science, dealing solely with mental conceptions. I am inclined to accept Prof. Peirce's extension and definition of it, that it is the science that draws necessary conclusions. But however we may extend or limit the science, it expresses necessary laws of our thinking, and it is not derogatory therefore to our highest knowledge that it is made subject to it. Moreover, our conceptions of the Creator become higher, as we are led on by our studies to emphasize the words of the Hebrew wise man, "Thou hast put together *all things* in measure, and in number, and in weight."

LIFE-HISTORIES OF THE CRUSTACEA AND INSECTS.

BY A. S. PACKARD, JR.

HAVING left the worms, we come now to a more circumscribed group of articulated animals, in which the jointed body is protected by a more or less dense tegument bearing jointed organs. The barnacles, water fleas, shrimps and crabs are tolerably familiar forms, and therefore we will not pause to discuss the anatomy and classification of these animals, merely premising our account of their development with the following tabular view of the main divisions of the group:

CRUSTACEA.

SUBCLASS I.	SUBCLASS II.
DECAPODA (Lobsters and Crabs).	TRILOBITA.
TETRADECAPODA (Sow Bugs, Beach Fleas).	MEROSTOMATA (King Crab).
NEBALIADÆ (Shrimp-like forms).	
PHYLLOPODA (Leaf-footed Shrimps).	
CLADOCERA (Water-fleas).	
OSTRACODA (Bivalved Water-fleas).	
COPEPODA, including SIPHONOSTOMA.	
CIRRIPEDIA including RHIZOCEPHALA (Barnacles).	

Development of the Barnacles. Before we turn to the life-history of the barnacles, let us look for a moment at the mode of development of those strange parasites, the Rhizocephala, whose larval feet become by a retrograde process of development converted into long irregular root-like extensions which ramify in the body of their host. The animal itself, as it adheres by means of its root-like feet to the under side of the abdomen of the crab on which it lives, would be readily mistaken for a large wart or sausage-like bunch. This shapeless mass is the mature Rhizocephalon, apparently the last term in the series of degradational forms so numerous among the lower Crustacea. This sac-like body is filled with eggs.

After total segmentation the embryo rapidly grows and hatches in an oval form with no distinct head, but with an oval shield-like disc covering the insertion of the three pairs of jointed swimming feet, ending in long bristles which aid in locomotion. This larval Rhizocephalon is comparable with the young of the water-fleas or

copepods, called "Nauplius' (see also Fig. 256), but differs from them in the shield-like expansion of the body, and in the presence of a distinct abdomen ending in a movable caudal fork. But however well developed is the body generally, the young root-barnacles, as we may term them, have no mouth, or so far as known, stomach or intestine, so that after swimming about freely for a few days, they change into the "pupa" state, in which they bear a remote resemblance to the bivalved Ostracodes.

The broad shield of the larva has now become folded together like the covers of a pamphlet, enclosing the body of the pupal root-barnacle. The foremost limbs (to avail ourselves of Fritz Müller's description in his "Facts for Darwin") have become transformed into very peculiar adherent feet (prehensile antennæ of Darwin). From the ends of these feet grow out two filaments which are possibly, as Müller suggests, the "commencements of the future roots." The two following pairs of feet are rejected, six pairs of forked swimming feet have meanwhile grown out on the abdomen, while the tail ends in two short appendages. These pupæ are also mouthless and soon attach themselves by means of their adherent feet to the abdomens of crabs and hermit crabs. The other feet drop off, the filaments grow down into the body of their host, entwining around the intestine or ramifying through the liver. "The only manifestations of life which persist in these *non plus ultras* in the series of retrogressively metamorphosed Crustacea, are powerful contractions of the roots, and an alternate expansion and contraction of the body, in consequence of which water flows into the brood-cavity and is again expelled, through a wide orifice" (Müller).

Such is the ordinary history of a Peltogaster or Sacculina, but Mr. Darwin tells us of another form (*Cryptophialus minutus*) which undergoes the larval state in the egg, hatching in the pupa condition, while another form (a species of Peltogaster?) also leaves the egg in the pupa form.

The barnacle has a somewhat similar life-history. It passes through a stage of total segmentation of the yolk and hatches as a Nauplius-like free-swimming larva, but differs from the Rhizocephalus larva in having a mouth, stomach and intestine, while the body is covered by a triangular shield, the anterior corners of which are prolonged into horns, while the posterior angle extends beyond the tail, the forked abdomen hanging down below this

long spine. The anterior feet (corresponding to the anterior antennæ) are simple, while the two pairs of posterior feet are forked, ending in long bristles.

These well armed creatures swim vigorously about on the surface of the water for a season, moulting several times before assuming the bivalve, pupal condition.

The pupa is almost identical in appearance with the bivalved Sacculina, having no mouth, and with a similar arrangement of limbs, except that no filaments are developed on the anterior pair of limbs, and they possess a pair of compound eyes.

The pupal condition is so much alike in the two groups, as stated by Fritz Müller, that we scarcely see why they should be separated as different groups, as Müller is disposed to regard them, but prefer to consider them as subordinate groups of Cirripedia.

The shield of the bivalved "pupal" barnacle becomes converted into the multivalved barnacle, the solid shell of the latter, as in the true sessile barnacles becoming so unlike the thin bivalves of the pupa, that, as is well known, even Cuvier supposed them to be mollusks, though there was the jointed feelers and the articulate plan of the nervous cord as witnesses of their crustacean affinities. The swimming feet of the larval barnacle become the long slender "cirri" which serve to draw in the food, creating currents setting in towards the mouth. Strange as is this retrograde development, we shall see it paralleled among the fish lice.

To sum up, the barnacles and root-barnacles, which are hermaphrodites, except in one family (Abdominales) pass through the following stages of development:

1. Morula.
2. Nauplius or larva.
3. A bivalved "pupal" stage.
4. Adult retrograde condition.

LITERATURE.

Thompson. Zoological Researches and Illustrations I. i. 1828–29.

Burmeister. Beiträge zur Naturgeschichte der Rankenfüsser. Berlin, 1834.

Darwin. A monograph of the subclass Cirripedia. 2 vols. London, 1851–54.

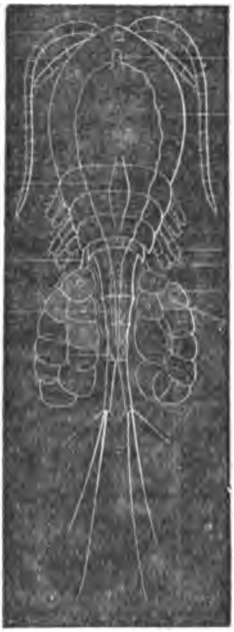
Müller, Fritz. Die Rhizocephalen. (Archiv für Naturgeschichte, 1862.)

Van Beneden, E. Recherches sur l' Embryogénie des Crustacés. III. (Bulletin de l'Acad. Roy. Belgique, 1870.)

Development of the Copepods. As the true Copepods and their allies, the fish-lice or Siphonostomatous Copepods, travel the same

developmental road until the larval stage is completed, the early stages here described apply to the species of both groups. The embryonic development, however, is very simple. The sexes are distinct, and the females (Fig. 235, *Cyclops quadricornis*, after Clark) in many cases swim about as seen in the figure, with a sac of eggs attached to each side of the body.

Fig. 235.



Cyclops.

The embryo in those species of Copepods which have been examined, is formed in the following manner, as observed by E. Van Beneden.

The egg undergoes total segmentation, resulting in a layer of blastodermic cells surrounding the yolk. These cells increase in length on one side, forming the blastodermic disc, or "primitive streak." On the ventral surface of this disc, viz., the side pointing outwards, the three pairs of limbs arise simultaneously, and the Nauplius (or larva) directly hatches, its body more or less oval and rounded.

In this simple condition, with no separation of the body into a head-thorax or abdomen, and with a simple unpaired eye and a labrum, it swims around. The farther transformations can be traced by any one who will take the pains to keep these water-fleas in aquaria.

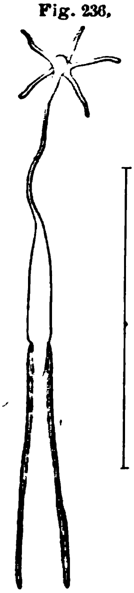
Before the larval Copepod leaves the egg it moults twice; the first is the "blastodermic skin" secreted by the blastodermic cells and exuviated before the limbs bud out. This blastodermic moult, comparable to the serous membrane of Arachnides and the true insects, has been observed by Van Beneden to be the larval membrane of Gammarus, and he has recognized it as surrounding the embryo of Sacculina, Leptomera, Caprella, Nebalia and Crangon.

The second or Nauplian moult takes place after the larval form is attained, but before the embryo hatches. The skin peels off when the appendages are of a certain length and before they are jointed.

At the moment of birth, says Van Beneden, the appendages

are distinctly jointed and provided with simple or branched bristles. The alimentary canal is distinct, so is the eye; and the nerve-ganglion is recognizable, while the blood circulates in the body-cavity.

Fig. 236.



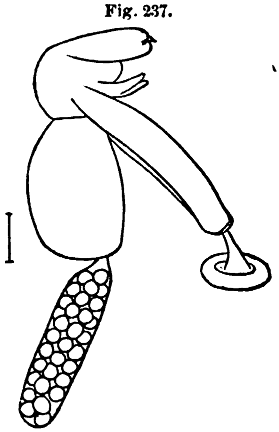
Fish Louse.

While most Copepods leave the egg in this perfected, Nauplius condition, the embryo Anchorella and Hessia, according to the researches of Van Beneden, pass through a Nauplius state in the egg, then three pairs of abdominal feet grow out, and an abdomen, consisting of five well marked segments, is differentiated from the cephalothorax. This stage is called the cyclopian stage by Van Beneden. Now this embryonic stage of the Lernæans, or fish lice, corresponds to the stages undergone by the free swimming young of Cyclops and other Copepods.

The Nauplius of Cyclops in growing to maturity elongates, mouth-appendages, abdominal segments and appendages arise after successive moults, until the adult form is attained.

In the parasitic genera, the larva is either a Nauplius, as in Achtheres and Chondracanthus (in Actheres the young has but two pair of appendages) or, as in Anchorella and others, a cyclops-like being, which after swimming around for awhile fastens itself by its appendages to the gills of some fish. Then begins the race between the organs of vegetative and animal life, the former far outstripping the latter. As in the Lernæa of the cod the appendages grow deep into the flesh of its host like twisted and gnarled roots, while the shapeless sac-like body is, as in the Sacculina, a simple sac filled with eggs. Or the body is still without segments, as in *Lerneonema radiata* (Fig. 236, from Verrill's Report) and ends in two attenuated ovaries; or as in *Actheres Carpenteri*, Fig. 237 (from Hayden's Report), which lives on trout, the deformation is less, and the body is divided into a head and abdomen, the latter in the female bearing two egg-sacs.

Fig. 237.



Fish louse.

To recapitulate the changes undergone by the Copepods in attaining maturity, they pass through the following phases of development:

1. Morula.
2. Nauplius.
3. Cyclopian (in certain genera embryonic) stage.
4. Adult Copepod, in some forms being a degraded more or less amorphous parasitic condition.

LITERATURE.

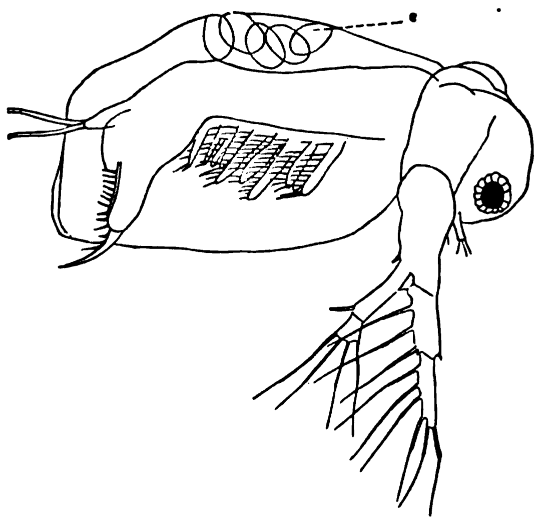
Nordmann. Mikrographische Beiträge zur Naturgeschichte der Wirbellosen Thiere. Berlin, 1832.

Claus. Ueber den Bau und die Entwicklung einiger parasitischer Crustaceen. Cassel, 1858.

Van Beneden, E. Recherches, IV. (Bull. Acad. Bruxelles, 1870.) See also Fritz Müller's Facts for Darwin. Translation. London, 1869.

Development of the Ostracodes and Cladocera. Of the life-history of the bivalved Ostracodes we only know from Claus' studies

Fig. 238.



Sida.

that "the youngest stages are shell-bearing Nauplius forms." It seems evident that these creatures undergo no metamorphosis.

Of the development of the Cladocera, such as the fresh-water Daphnia and Sida (Fig. 238, from Hayden's Survey) we have more certain knowledge. The eggs are borne by the females in

so-called brood-cavities on the back under the shell. The females bring forth two sorts of eggs, *i.e.*, the "summer eggs," which are laid by asexual females, the males not appearing until the autumn, when the females lay the fertilized "winter eggs," which are surrounded by a very tough shell.

Dohrn observed the development of the embryo in the summer eggs. At first the embryo has but three pairs of appendages, representing the antennæ and two pairs of jaws. It is thus comparable with the Nauplius of the Copepods, and thus the Cladocera may be said to pass through a Nauplius stage in the egg.

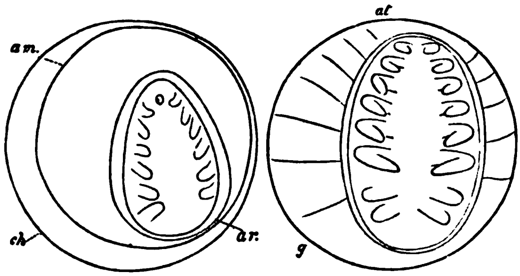
Afterwards more limbs grow out, until finally the embryo is provided with the full number of adult limbs, and hatches in the form of the mature animal, undergoing no farther change of form.

LITERATURE.

Dohrn. Untersuchungen ueber Bau und Entwicklung der Arthropoden. Leipzig, 1870.

Development of the King Crab (Limulus). Here we must turn aside from the true Crustacea to study the development of the king crab, so unlike in its organization to the normal Crustacea, and remarkable for being an ally of the trilobites.

Fig. 239. Fig. 240.



Embryo of King Crab.

Unlike most Crustacea the female king crab buries her eggs in the sand between tide marks, and there leaves them at the mercy of the waves, until the young hatch. The eggs are laid between the end of May and early in July, and the young are from a month to six weeks in hatching.

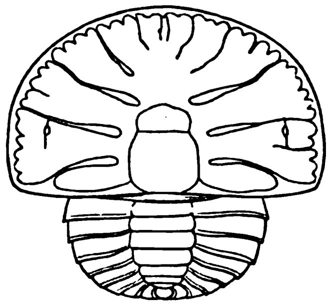
After fertilization the yolk undergoes partial segmentation, much as in the insects. When the primitive disk is formed (much as in the spiders and certain crabs) the outer layer of blasto-

dermic cells peels off soon after the limbs begin to appear, and this constitutes the serous membrane (Fig. 239, *am*) which is like that of insects.

Then the limbs bud out, the six pairs of cephalic limbs appear at once as in Fig. 239. Soon after the two basal pairs of abdominal leaf-like feet arise, the abdomen becomes separated from the front region of the body, and the segments are indicated as in Fig. 240. A later stage is signalized by the more highly developed dorsal portion of the embryo, an increase in size of the abdomen, and the appearance of nine distinct abdominal segments. The segments of the cephalothorax are now very clearly defined, as also the division between the cephalothorax and abdomen, the

Fig. 241.

Fig. 242.



King Crab shortly before hatching; trilobitic stage.

latter being now nearly as broad as the cephalothorax, the sides of which are not spread out as in a later stage.

At this stage the egg-shell has split asunder and dropped off, while the serous membrane has increased in size to an unusual extent, several times exceeding its original dimensions and is filled with sea water in which the embryo revolves.

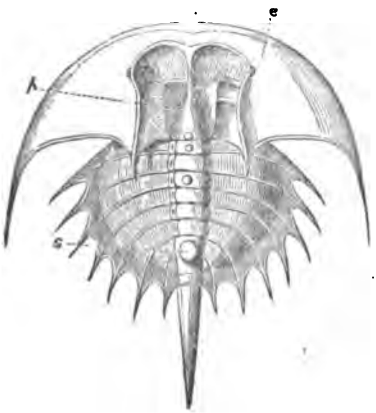
At a little later period the embryo throws off an embryonal skin, the thin pellicle floating about in the egg. Still later in the life of the embryo the claws are developed, an additional rudimentary gill appears, and the abdomen grows broader and larger, with the segments more distinct; the heart also appears, being a pale streak along the middle of the back extending from the front edge of the head to the base of the abdomen.

Just before hatching the head-region spreads out, the abdomen

being a little more than half as wide as the cephalothorax. The two compound eyes and the pair of ocelli on the front edge of the head are quite distinct; the appendages to the gills appear on the two anterior pairs, and the legs are longer.

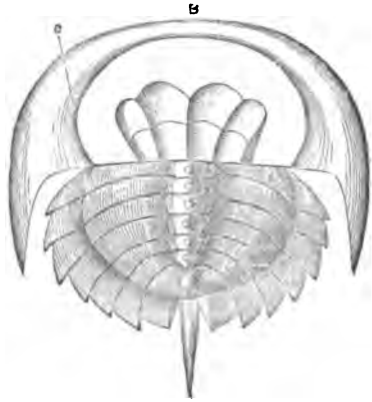
The resemblance to a Trilobite is most remarkable, as seen in Figs. 241 and 242. It now also closely resembles the fossil king crabs of the Carboniferous formation (Fig. 243, *Prestwichia ro-*

Fig. 243.



Prestwichia.

Fig. 244.



Euproöps.

tundatus, 244, *Euproöps Danæ*, from Worthen's Paleontology of Illinois).

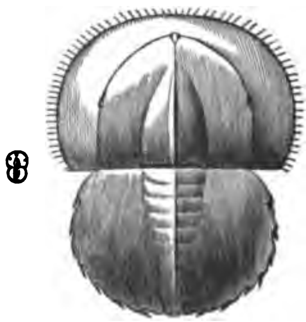
In about six weeks from the time the eggs are laid the embryo hatches. It now differs chiefly from the previous stage in the abdomen being much larger, scarcely less in size than the cephalothorax; in the obliteration of the segments, except where they are faintly indicated on the cardiac region of the abdomen, while the gills are much larger than before. The abdominal spine is very rudimentary; it forms the ninth abdominal segment.

The reader may now compare with our figures of the recently hatched Limulus, that of Barrande's larva of *Trinucleus ornatus* (Fig. 246, natural size and enlarged). One will see at a glance that the young Trilobite, born without any true thoracic segments, and with the head articulated with the abdomen, closely resembles the young Limulus. In Limulus no new segments are added after birth; in the Trilobites the numerous thoracic segments are added during successive moults. The Trilobites thus pass through a

well marked metamorphosis, though by no means so remarkable as that of the Decapods and the Phyllopods.

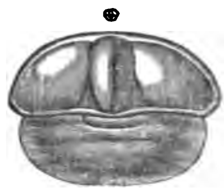
The young swim briskly up and down in the jar, skimming about on their backs, by flapping their gills, not bending their bodies. In a succeeding moult, which occurs between three and four weeks after hatching, the abdomen becomes smaller in proportion to the head, and the abdominal spine is about three times as long as broad. At this and also in the second, or succeeding moult, which occurs about four weeks after the first moult, the

Fig. 245.



Larva of the King Crab.

Fig. 243.



Larva of a Trilobite.

young king crab doubles in size. It is probable that specimens an inch long are about a year old, and it must require several years for them to attain a length of one foot.

The stages of growth, to recapitulate, are as follows: —

1. Peripheral or partial segmentation of the yolk.
2. No true Nauplius stage, but the six legs appear simultaneously.
3. Trilobitic stage.
4. Adult Limulus form attained before hatching.

LITERATURE.

Packard. The Development of Limulus Polyphemus (Memoirs Boston Society of Natural History. 1872.)

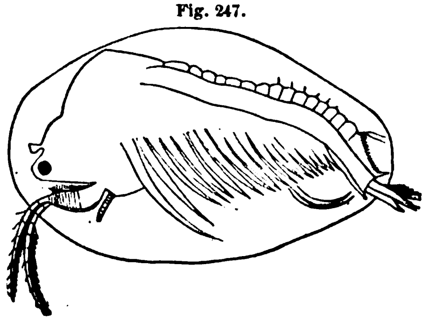
Consult also papers by Lockwood, Dohrn, and E. Van Beneden.

Development of the Phyllopods. We will now return to the true Crustacea, and trace the mode of growth of the leaf-footed forms, beginning with Limnadia (Fig. 548, *L. Agassizii* Packard, in Hayden's Report), a form with whose development we are acquainted.

These shelled crustaceans live in pools which often dry up in summer. The eggs after leaving the oviduct are arranged above the back under the carapace, where they remain for one or two days in midsummer, or for several days during September. The eggs of the European *L. Hermanni* are irregular in form and enclosed in a solid calcareous shell composed of two valves. So thick is the shell that Lereboullet was unable to study the development of the embryo.

The young are hatched in from five to ten days after the expulsion of the eggs from under the carapace. The freshly hatched larva is a nauplius, with the body rather long and with two pairs of appendages bearing bristles, the anterior pair being forked; there is a single eye in the middle of the head and an enormous labrum. Lereboullet states that the larvæ "have a great resem-

Fig. 247.



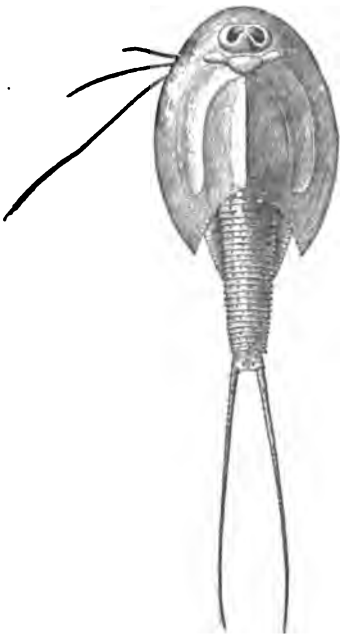
Limnadia Agassizii.

blance with the larvæ of other branchiopod crustacea, among others with those of Branchipus and Artemia. But the larvæ of these two genera have antennæ, which are wanting in the larvæ of Limnadia, while also the larvæ of Artemia have no labrum." About the beginning of the second or third day, the two halves of the carapace begin to grow out from the sides of the base of the abdomen. They finally unite over the back forming a sort of a hinge, and at length enclose the body, with the exception of the head and extremity of the abdomen. When the creature is fully grown, the head and tail are entirely covered by the shells of the carapace. I have found the young of *L. Agassizii* about half a line in length in a pool on Penikese Island early in August. The pool a few days after dried up, and these young met the fate so common to these Phyllopods, but the eggs, protected by their solid calcareous cov-

ering, undoubtedly withstand the desiccation for over one year, and thus the species is preserved.

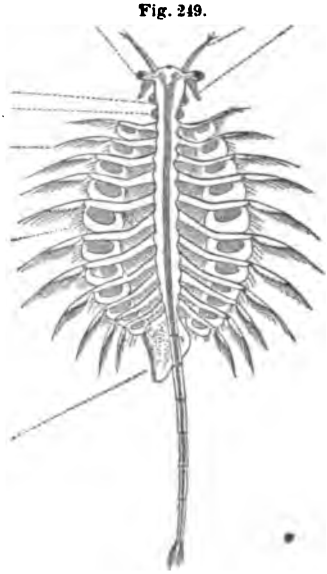
The larval development of *Apus* (Fig. 248, *A. æqualis* Packard, in Hayden's Report) has been studied by Zaddach. We know nothing of the embryology of this animal. I have, however, been able to discover that the blastodermic skin, like that of Limulus, consists of a single layer of moulted cells. Zaddach represents the chorion, or egg-shell, as splitting apart just as in Limulus, and

Fig. 248.



Apus æqualis.

Fig. 249.



Brine Shrimp, Artemia.

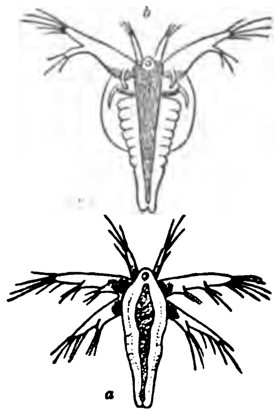
the embryo surrounded by an inner membrane, which is the blastodermic skin.

The young breaks out of its blastodermic skin in the nauplius form with two pairs of appendages. After a moult a third pair is added and the larva appears as in Fig. 250, *b*. The numerous foliaceous feet, to the number of sixty, are added during subsequent moults.

Of the embryological development of Branchipus and Artemia (Fig. 249, *A. gracilis*, after Verrill) we also know nothing. The

young is hatched in a nauplius condition (Fig. 250, *a*) but with three pairs of limbs. I have observed a similar nauplius-brood in the *Artemia fertilis* of Great Salt Lake. As in Apus, new pairs are added at subsequent moults until the adult form is attained. Siebold has shown that the summer broods of females reproduce by budding, as is probably the case in Limnadia and also Branchipus and Artemia, the males not appearing until towards autumn, though I have found males of *Artemia fertilis* in great abundance in Great Salt Lake late in July. Fig. 251 represents *Branchipus* (Branchinectes) *Coloradensis* (Packard, in Hayden's Report), the female being distinguished by the short clasping antennæ, and the long egg-sac at the base of the abdomen.

Fig. 250.



Larva of Apus: *a*, Artemia.

The Phyllopods, then, with whose embryological development we are not acquainted, after hatching pass through a nauplius stage, and the adult condition is attained after a number of moults.

LITERATURE.

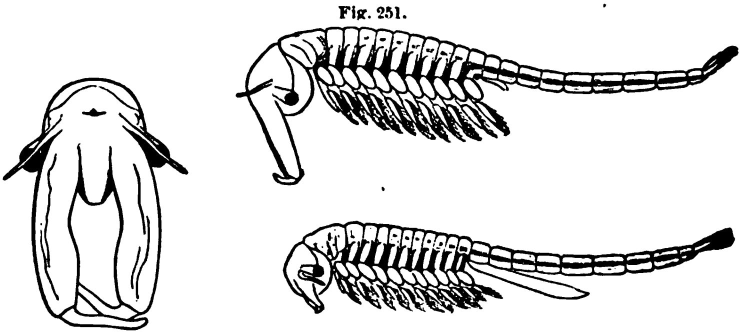
Joly. Histoire d'un petit Crustacé (Artemia salina), etc. (Annales des Sc. Nat., 1840.)
Zaddach. De Apodis cancriformis Anatome et Historia Evolutionis. Bonn. 1841.
Lereboullet. Observations sur la Génération et le Developpement de la Limnadia Hermanni. (Annales des Sc. Nat., 1866.)

Development of Nebalia. A great degree of interest attaches to the life-history of this animal, which is not uncommon in deep water off our coast. It is a relict of a group still older than the king crab, being represented in the primordial rocks by Hymenocaris, and in lower Silurian strata by Discinocaris and Peltocaris, and in the upper Silurian by Ceratiocaris and other forms, gigantic in size (some of them being about seven inches long) compared with the recent Nebalia, which is about half an inch in length. Nebalia is regarded by Metschnikoff as a Decapod; it may be regarded at least as a connecting link between the Phyllopods and Decapods, and as a prophetic type preceding, in paleozoic time, the introduction of the mesozoic Decapods.

Judging by the plates of Metschnikoff's memoir, for the text is written in Russian (a sealed language to us), the early develop-

ment of Nebalia is apparently identical with that of Oniscus, as studied by Bobretzky, and probably all the Tetradecapods, and also with that of perhaps the majority of the Decapods. As in Oniscus the segmentation is partial, the blastodermic cells arising from the subdivision of a polar cell, finally forming a blastodermic disk consisting of a few large cells. At first but three pairs of appendages arise; these corresponding to the two pairs of antennæ and the third to the mandibles. At this period the abdomen is distinct from the cephalothorax, but on the whole the embryo may be said to pass through a nauplius stage.

Fig. 251.



Branchinectes Coloradensis and front view of head of the male.

Then the two pairs of maxillæ and two pairs of feet arise simultaneously, the abdomen increases considerably in length, when the ten other pairs of foliaceous feet spring forth. Meanwhile the bivalved carapace grows out from behind the eyes, covering the cephalothorax and base of the abdomen. The young hatches soon after the shield is developed and the further changes are but slight.

The Nebalia, then, in brief, passes through the following stages:

1. Partial segmentation of the yolk.
2. Nauplius stage (in the egg).
3. Larval form like the adult; with no metamorphosis.

LITERATURE.

Metschnikoff. The History of the Development of Nebalia. (In Russian.) St. Petersburg, 1868.

Development of the Tetradecapods. Much good work has been done since the days of Rathke, on the mode of growth of the fresh

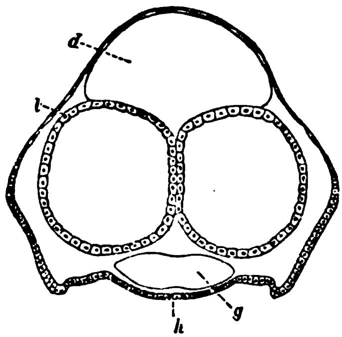
and salt water sow-bugs, etc. (Isopods), and the beach fleas (Amphipods). The development of the *Asellus aquaticus* of Europe has been studied by E. Van Beneden. He found that the segmentation of the yolk is partial; that after a blastodermic moult the two pairs of antennæ are formed before the mandibles and maxillæ, the embryo passing through a Nauplius phase. At this time the embryo moults again. Like all Tetradecapods the young hatch in the form of the adult, there being no metamorphosis. Perhaps the most careful study of the embryology of the higher crustacea, with the improved means of examination instituted mainly by Kowalevsky, is that of *Oniscus murarius*, a sow-bug, by Dr. N. Bobretzky, a student of the eminent Russian zoologist. The following is an abstract of his paper. The egg is provided with a chorion and yolk skin. The first change after fertilization is the origin of the formative or original blastodermic cells, which arise at one pole of the egg. As a result of the self-division of the single primitive blastodermic cell, there arises a disk corresponding to the primitive streak of other articulates, consisting of a single layer of large spheres of segmentation. It thus appears that the segmentation is partial.

Before one-half of the surface of the egg is covered, the middle and inner germ-layers are indicated by a mass of cells in the concavity of the outer layer, resulting from the division of some cells of the outer layer. This primitive mass is the first indication of the innermost (third) and middle layers. The third or inner layer consists of large cells mingled with the yolk cells, among which they press. (He finds this to be the case also in Crangon and Palæmon.) There are, then, three germ-layers as in the vertebrates.

The primitive disk, or streak, then forms by the cells of the outer layer assuming a cylindrical form. The first indication of the intestine is an invagination of the hinder end of the primitive band. A larval skin, like that of Asellus and other crustacea, arises when the first traces of the appendages appear. Bobretzky finds that, contrary to Kowalevsky's opinion, the inner germ-layer in the crustacea agrees with that of vertebrates. Soon after the limbs grow out, a cross-section shows that it is due to a bulging out of the outer germ-layer, the cavity being filled with cells of the middle layer. Now appear the first indications of the liver, a layer of large cells forming the liver sac. After the appendages

appear, the nervous cord arises as a thickening of the outer layer on the ventral side of the primitive band, and consists of three or four layers of roundish cells. Fig. 252 (this and Fig. 253, after Bobretzky) is a transverse section of an embryo in nearly the same stage as the embryo Amphipod (Fig. 254); *d* indicates the intestine, and *l*, the two lobes of the liver; *g*, a transverse section of the nervous cord, and *h*, the walls of the body (hypodermal layer). The opening of the liver into the intestine is shown in another section made and drawn by Bobretzky.

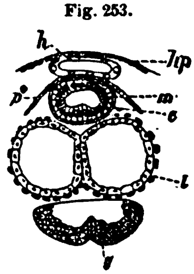
Fig. 252.



Section of Embryo Sow-bug.

One of the most difficult problems to solve in the embryology of the Arthropods is the origin of the large intestine. It is known that it arises out of the yolk sac, but how and where it takes its origin remained without an answer. "After I had ascertained," says Bobretzky, "in the Astacus and Palæmon the peculiar relation of the intestino-glandular cells to the yolk, I could, in these Crustacea, follow step by step the origin of the epithelium constituting the walls of the large intestine. This epithelium first appears in the liver sac." He found the same mode of origin in Oniscus. The next step is the disappearance of the yolk, while the large intestine is fully formed, but there is as yet no communication with the stomach, there being a double wall of cells shutting off the large intestine.

Fig. 253.

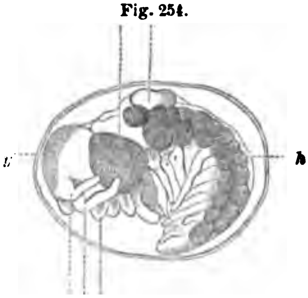


Section of advanced embryo Sow-bug.

The heart is the last to be formed; it arises from the middle layer, though Bobretzky was unable to study its early development. Fig. 253 is a transverse section of the body showing the viscera; *h*, indicates the heart; *hp*, hypodermal layer, or body wall; *m*, muscular wall of the intestine; *e*, epithelial lining of the intestine; *p*, the dividing wall between the heart and the intestine; *l*, the two lobes of the liver; *g*, ganglion, the clear space being filled with the fine granular substance of the ganglion. Nothing

has been said of the development of the external parts. The two antennæ in Oniscus and Asellus are the first to bud out (Nauplius stage) and then the remaining appendages of the head and thorax appear together, and subsequently the abdominal feet are formed. The abdomen is curved up and backwards, while in the Amphipods it is bent beneath the body, as in Fig. 254, and this is really, as Fritz Müller observes, the only important difference between the embryos, at an early stage, of the two groups. The embryo Isopod at the time of hatching closely resembles the adult, there being no metamorphosis.

Fig. 254.



Embryo of an Amphipod.
h, head; *a'a'*, antennæ; *y*, yolk; *m*, mouth-parts.

The development of the Amphipods or beach fleas, is nearly identical with that of the Isopods. The eggs of certain species undergo total segmentation, while those of other species of the same genus (Gammarus) partially segment, as in the spiders, and in a less degree the insects, showing the slight importance to be attached to this matter, and that Hæckel's term *Morula* when used for the total segmentation of Crustacea is of little significance, how much it may be in the lower animals. It should be borne in mind that it has been used in the present work mainly as a convenient term to avoid circumlocution.

Fig. 254, after Müller, represents the embryo of a Corophium, magnified ninety diameters, in which all the limbs are developed.

Summary of changes:—

1. Segmentation of the yolk partial, or total (Morula).
2. Nauplius state in the egg.
3. Larva hatching in the form of the adult with the full number of feet; no metamorphosis.

LITERATURE.

Van Beneden, E. L'Oeuf. Brussels, 1870.

——. Recherches sur l'Embryologie des Crustacés, I. (Bull. Acad. Bruxelles, 1869.)

Dohrn. Die embryonale Entwickelung des Asellus aquaticus. (Siebold and Kölliker's Zeitschrift. 1857.)

——. Zur Morphologie, Reisebemerkungen aus Taurien. Leipzig. 1837.

Rathke. Untersuchungen ueber die Bildung und Entwickelung der Wasser-Assel (Asellus aquaticus). Leipzig, 1832.

Bobretzky. Zur Embryologie des Oniscus murarius. (Siebold and Kölliker's Zeitschrift. 1874.)

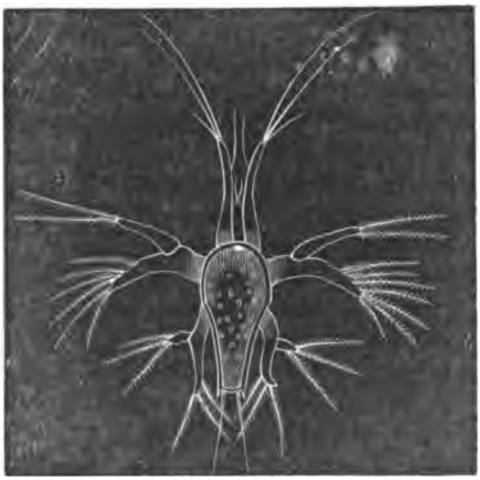
Development of the Decapods. When we come to the stalk-eyed Crustacea, such as the shrimps and crabs, we are introduced to a group of animals in which there is a most striking metamorphosis, as first shown by Thompson. The life-history of a Decapod is full of interest and significance, as the phases which some present from the larval stage up are as varied and astonishing as the biography of any animal known. In the group as a whole, we have species in which the metamorphoses are performed in great detail and complexity of form, the animal shifting its garb as if an actor with many parts to perform in the drama of life, while in its co-species these phases may be mostly suppressed, and the few it does undergo, rapidly assumed and discarded within the narrow compass of the egg-shell.

One Decapod, the shrimp Penæus, studied by Fritz Müller, on the coast of Brazil, is an exception to all other stalk-eyed Crustacea in hatching as a true nauplius, and then by a complicated series of metamorphoses assuming the zoëa and finally adult life. On the other hand, there is the common lobster, or fresh water craw fish, whose free nauplius and zoëa stages are suppressed, undergone in the egg, and which hatches in nearly or quite a similar form to the fully grown animal. Between these stages there are all grades in other Crustacea.

As regards the development of the embryo, there is in those species which undergo a metamorphosis, a quite similar mode. The yolk so far as known (Scyllarus, Astacus, etc.) undergoes partial segmentation: no case of a total division is as yet known. After the formation of a short round primitive streak, or band, the limbs arise. In several cases observed by Dohrn, the three anterior pairs of limbs, namely, the two antennæ and the mandibles were developed simultaneously and before the others appear. The embryo may with truth, then, as Dohrn states, be said to pass through a nauplius condition in the egg, as much as a mammal passes through a fish-like stage. He observed this nauplius-stage in the embryo of Scyllarus, Pandalus and Galathea. I have observed it in *Lupa hastata* at Charleston, S. C., and *Libinia canaliculata*. It is not improbable that most crabs pass through a nauplius state. As if in proof of the supposition held that this is a true nauplius *in embryo*, we have the fortunate discovery, by Fritz Müller, of the fact that a Brazilian shrimp (Penæus, allied to *P. setiferus* of Florida) leaves the egg "with an unsegmented ovate body, a median frontal eye, and three pairs of natatory feet,

of which the anterior are simple, and the other two biramose; in fact, in the larval form, so common among the lower Crustacea, to which O. F. Müller gave the name of *Nauplius*. No trace of a carapace! No trace of the paired eyes! No trace of masticating organs near the mouth which is overarched by a helmet-like hood!" Let us, with Müller, follow the subsequent history of this young shrimp. After passing through the nauplius condition (Fig. 255) it acquires several pairs of appendages (maxillæ and maxillipedes), but as yet no true legs. It is now a typical zoëa (Fig. 256) having two compound eyes, a carapace and a jointed body. The next

Fig. 255.



Nauplius, or larva, of a Shrimp.

important step is the appearance of the five pairs of thoracic feet, and soon the mature form of the prawn is attained.

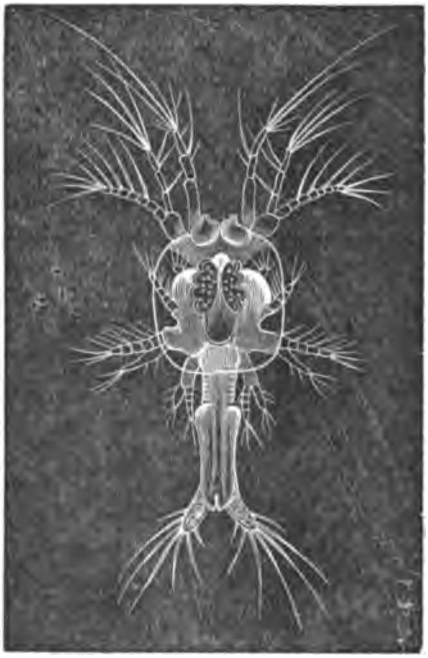
Most true Decapods, namely, the shrimps and crabs, are hatched as zoëæ (Fig. 257 after Thompson, represents the zoëa of *Carcinus mœnas*), and swim about awhile in this state, the swimming feet being the antennæ and jaws and foot jaws, which afterwards acquire a digestive function.

Now one species of the genus Alphcus, observed by the writer at Key West, is hatched in a more advanced condition; in what may be called a super-zoeal state, namely, it possesses not only five pairs of thoracic feet, but also five pairs of swimming, biramose abdominal feet, with the characteristic large claw! Here we have a sup-

pression of a true zoëal free swimming condition, just as we have seen to be the case in all the other groups of the animal kingdom, where one species may be born in an extremely imper ect condition, and another, even of the same genus, is born n a very perfect state, the intermediate phases being rapidly assumed and as rapidly discarded in the embryo.

A less extreme case is that of the lobster, which hatches without abdominal feet, but still with well developed thoracic legs. The

Fig. 256.



Zoëa of the same Shrimp.

larva is super-zoëal. The most extreme case, namely of an entire absence of a metamorphosis, is the cray-fish (Astacus and Cambarus), which hatches exactly in the form of the parent.

These facts are paralleled by the metamorphosis of the insects, where the terms "larva" and "pupa" are exceedingly arbitrary, the larval bee or fly attaining maturity only after a series of surprising changes, while the larval grasshopper simply differs from e adult in having no wings.

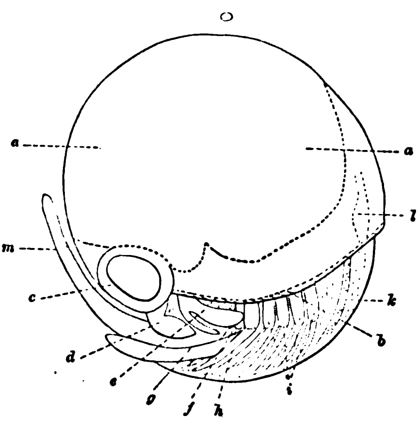
Crabs breed all through the spring and summer. At Charleston, S. C., on the 12th of April, I found the eggs of the edible crab, *Lupa hastata*, containing embryos in all stages of development from the nauplius to the zoëa. The fiddler crabs (*Gelasimus pugnax*) at Fort Macon, N. C., during the middle of May, carried eggs in which the polar cells, or formative cells of the blastoderm, were present, while others contained zoëæ, with the two claws alike, and it is probable that the strange inequality in size of the claws in these animals does not show itself until after one or more moults.

Fig. 257.

Zoëa of a Crab.

The development of the lobster has been studied with much care by Prof. S. I. Smith. The lobster breeds between April and November. Fig. 259[1] represents the embryo just before hatching. After hatching it swims

Fig. 258.



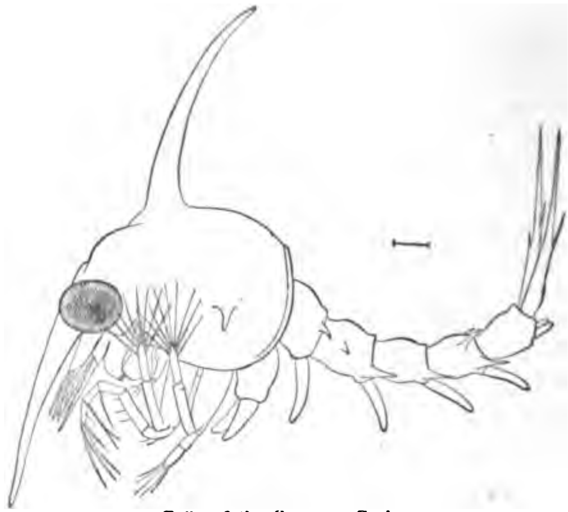
Embryo of the Lobster.

around with the thoracic feet. After moulting, the abdominal feet

[1] Fig. 258. Embryo some time before hatching, removed from the external envelope and shown in a side view, enlarged 20 diameters. *aa*, dark green yolk mass still unabsorbed; *b*, lateral margin of the carapax marked with many dendritic spots of red pigment; *c*, eye; *d*, antennula; *e*, antenna; *f*, external maxilliped; *g*, great cheliped which forms the big claw of the adult; *h*, outer swimming branch of the same; *i*, the four ambulatory legs with their exopodal branches; *k*, intestine; *l*, heart; *m*, bilobed tail seen edgewise. After Smith.

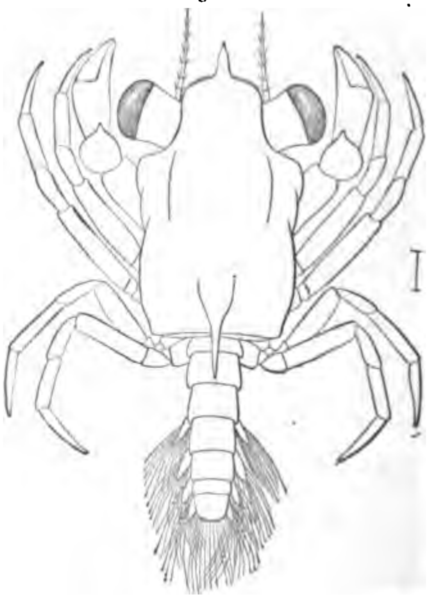
arise. After a second moult it is half an inch long and loses its

Fig. 259.



Zoëa of the Common Crab.

Fig. 260.



Megalops of the Common Crab.

formerly Mysis-like appearance and closely resembles the adult.

Soon after this it leaves the surface of the water and seeks the bottom. Specimens three inches long are quite like the adults.

Besides the zoëa stage, many crabs pass through a stage intermediate between the zoëa and adult. This is called the *Megalops* stage, as it was supposed to be an adult animal and described under this term, just as early observers mistook the Nauplius and Zoëa for adult Crustacea. Fig. 259 *a* (this and 260 after Smith) represent the zoëa of the common Crab (*Cancer irroratus*) in the last stage just before it changes to the megalops condition, and Fig. 260 the megalops of the same, magnified thirteen diameters. In two cases, *Eriphia spinifrons*, and a species of Gecarcinus, or the land crab of the West Indies, there is no metamorphosis, the young being like the adult.

Summary of the life-history of the Decapods:

1. Partial segmentation of the yolk.
2. Nauplius stage; either free swimming or undergone in the egg.
3. Zoëa stage; sometimes suppressed.
4. Megalops stage; in many crabs; in a few cases no metamorphosis.
5. Adult.

LITERATURE.

Rathke. Untersuchungen ueber die Bildung und Entwickelung des Flusskrebses. Leipzig, 1829.

Thompson, J. V. On the double metamorphosis in the Decapodous Crustacea. (Phil. Trans. London, 1835.)

Müller. Facts for Darwin. 1869.

Dohrn. Untersuchungen ueber Bau und Entwicklung der Arthropoden. (Siebold and Kölliker's Zeitschrift. 1870. Jenaischen Zeitschrift. V. 1871.)

Smith. The metamorphoses of the lobster and other Crustacea (in Baird's Report on Fish and Fisheries, U. S. 1873).

With papers by Thompson, Rathke and Claus.

II. THE INSECTS. (Tracheata.)

Under the term Insecta may be included the three groups of Myriopods, Arachnids and true six-footed insects, or Hexapoda. All differ from the Crustacea in having, as a rule, for there are exceptions among the mites, a distinct head, separate from the thorax, and in breathing by internal air-tubes (tracheæ) instead of external gills. Without spending much time in describing the metamorphoses of the winged insects, accounts of which may be found in any entomological work, we will briefly describe their embryological development, from sources less generally accessible.

Development of the Myriopods. Though Newport's classical memoir on the development of Julus will be found useful for the post-embryonic stages, the indefatigable Metschnikoff has recently cleared up the embryological development of these animals, so that we are now in possession of a life-history of these creatures, the early phases of whose existence had thus far eluded the scrutiny of embryologists.

We will now follow Metschnikoff in his studies, beginning with the history of a Polydesmus-like form, *Strongylosoma Guerinii*, an inhabitant of the island of Madeira. The eggs were laid during a period extending from February to the end of May. Before ovipositing the female buries herself in the earth one or more inches below the surface, then depositing one or two hundred eggs in the manner of several other Myriopods. The eggs are spherical, yellowish-white, and from 1–3 mm. in diameter.

The egg undergoes total segmentation, the process beginning in six or eight hours after it is laid, and ending on the fourth or fifth day. By this time the primitive band rests on the outside of one-half of the egg. A furrow next arises (as in the first figure of the Podurid, Isotoma) on each side of which the primitive ridges afterwards swell up. The two germ-layers now arise, the inner originating in a small mass of cells on each side of the furrow. The antennæ bud out, and subsequently three additional pairs, namely, the mandibles, the second maxillæ (the first pair wanting in the Chilognaths as in the Poduridæ) and the first pair of legs; and now the two ends of the body meet over the yolk as in the Podurids, the head touching the tail.

The brain is now formed from the outer germ-layer (ectoderm), the mouth and anal opening also being formed by an invagination of the same outer layer, the inner layer constituting ultimately the muscular walls of the digestive tract, while the epithelial lining of the large intestine also arises from the inner germ-layer.

On the fifteenth, and early on the sixteenth, day the "boring apparatus," a chitinous point by which the embryo cuts open the shell, appears on the head. The legs now assume their form, the fourth and fifth pair belonging to a single segment. The embryo now moults, the skin forming a cuticle enveloping the embryo after the shell splits asunder. The nervous cord arises from the middle portion of the upper germ-layer, though the division of the layer into an epidermal and nerve-layer has not yet taken place.

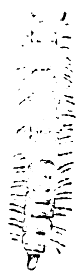
By the sixteenth, the chorion is cut through by the point of the egg-shell breaker when it splits apart, and the embryo thus remains covered by this membrane until the larvà is ready to creep about, a curious fact first observed in Julus by Newport.

By the seventeenth day nine or ten true segments are formed, and the appendages begin to show articulations, while beneath the skin, the fourth, fifth and sixth pairs of feet arise as little sacs, opening in the middle line of the body. The two stigmata arise as a fine tube with a small opening on the basal end of the third pair of feet, the walls of the tube (trachea) being due to an in-pushing of the outer germ-layer. The epidermis is now well defined and the nervous cord is isolated from the skin, while on the nineteenth, or last day of embryonal life, the hairs arise over the body. The embryo would now easily be mistaken for a Podurid so remarkable is the resemblance, owing to the similar number of body-segments, and the large head, wanting in both animals the true maxillæ.

On the twentieth day the larva breaks through the membrane, and the head is clearly separated from the body. The larva closely resembles the young Julus, being as yet cylindrical, and having but nine rings besides the head.

In *Polydesmus complanatus* of the Madeira islands, the egg also undergoes total segmentation, but the embryo develops more rapidly, being by the fifth day covered with a membrane. Meanwhile the antennæ have appeared, and on the sixth day five additional pairs of limbs bud out, namely, the mandibles, second maxillæ (labium) and three pairs of legs. There is no shell breaker, the shell bursting, however, on the tenth day. The mandibles are very large, almost covering the labium. The larva is cylindrical, the body (the head excepted) consisting of seven segments.

Fig. 261.



Polydesmus.

The development of the singular *Polyxenus lagurus*, a little short creature with the body covered with fascicles of hairs, was observed by the Russian embryologist in Switzerland.

The egg undergoes total segmentation, but the blastoderm is restricted to one pole of the egg, being disk-like. The antennæ and mouth-parts arise as in the foregoing genera, but the three pairs of legs appear simultaneously. Metschnikoff found amœ-

boid bodies, like those in the mites, moving about in the egg, having previously separated from the blastoderm.

We now come to the development of the Thousand-legs (Fig. 262) which was first studied by Newport. Our skilful Russian embryologist, with all the advantage of modern means of investigation, and possibly by observing more transparent eggs than those studied by the famous English zoologist, has thrown a flood of light on the embryonic stages of a species (*Julus Morelettii*) observed by him in Madeira. The eggs were laid in November, rarely in the spring, and not at all in the summer, being deposited in rounded masses under the surface of the earth, as in the other Chilognathic myriopods. They are oval, dirty greenish white, with the shell unfortunately more opake than in the other genera mentioned. Here, also, as in the others, the segmentation was total, a thing not known to occur in the Hexapods (the Podurids excepted), and rarely in the Arachnids, chiefly in the mites. The primitive band arises on one side. There is a blastodermic moult, like that of many Crustacea, and corresponding to the "deutovum" of certain Acari. The two germ-layers were observed to arise as in the other genera, while the three cephalic appendages (antennæ, mandibles and second maxillæ) appear as in the other Myriopods.

Fig. 262.

Julus.

The shell splits, as first observed by Newport, and the retort-shaped embryo remains enveloped in the blastodermic skin, remaining connected with the chorion by a fine structureless membrane. By this time four additional pairs of limbs, like little buds, are visible under the larval skin, which is homologous with that of the Isopods. The head is free from the thorax, and the body composed of eight segments. The embryo before hatching is as in Fig. 263 (after Newport), there being no feet on the third ring from the head. This, however, is not apparently a fact of much morphological importance, as in Geophilus the embryo has a pair of feet on each body segment. In the figure, *a* indicates the rudiments of the new limbs, and *b*, the six new rings growing out from between the penultimate and last ring of the body.

Fig. 263.

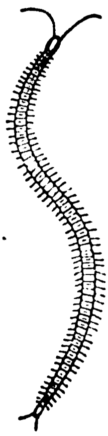
Larva of Julus.

Metschnikoff discovered in all the embryo Myriopods studied by him certain paired bodies which he names "primitive-vertebræ-like bodies." He has also noticed them in the Scorpion, the Phalangids, Araneids, Mysis and some other Crustacea, Termes and several Oligochete worms.

When we turn to the embryology of the Poduridæ we shall see how much alike those insects and the Chilognaths are in the mode of development of the embryo, and should also bear in mind the fact that the Poduras also have but a single pair of maxillæ, while Scolopendrella is half insect and half Myriopod. The conclusion that the Myriopods are a subclass of the class of insects is thus based on morphological and embryological grounds.

A later paper of Metschnikoff's gives us, for the first time, the life-history of Geophilus, one of the Centipedes or Chilopod Myriopods. He found that the yolk undergoes a total segmentation, and the primitive band surrounds one-half of the yolk. In the next stage observed the antennæ and three pairs of jaws were developed (for there are besides the mandibles, two pairs of maxillæ, like those of insects, in the Centipedes) besides twenty-three segments. The anal opening was situated in the unsegmented end of the body. In the next stage the primitive band is much longer than before, and the head and tail approach nearer to each other, while there are now from forty-four to forty-six body segments, most of them bearing rudimentary appendages, though there are none as yet on the end of the body. In a succeeding stage the head is much larger, the body longer and curved over the yolk, while the egg-shell breaker is situated on the second maxilla. In a following stage the body is still more elongated and the joints of the antennæ appear. The embryo now slips out of the split shell, the body being very long and cylindrical, not yet flattened as in maturity (Fig. 264 represents an American Geophilus), while the feet are not jointed, and resemble the ventral cirri of annelides.

Fig. 264.



Geophilus.

We see then that the Centipedes (Chilopoda) differ from the Thousand-legs (Chilognaths) in the mouth-parts being of the same number as in insects, and that the young are born with a pair of feet on each of the three segments behind the head, while the

larva is provided with nearly the full number of feet on the rest of the body, there being no metamorphosis. The body, at first cylindrical, afterwards becomes flattened. Thus the Centipedes may be said in some degree to pass through a Julus condition, and at all events, both morphologically and embryologically, the Centipede is a more highly developed creature than the Thousand-legs, a view we have always taken, but felt was rather based on *a priori* conceptions than on a sure basis of facts, now happily afforded by the beautiful researches of Metschnikoff. To sum up the phases of development of the Myriopods we have, then:—

1. Morula stage.
2. A hexapod larva (Leptus form) as in the Thousand-legs; or, as in the Centipedes, there is no metamorphosis, the young being like the parent.
3. Adult.

LITERATURE.

Newport. On the Organs of Reproduction, and the Development of the Myriopoda. (Phil. Trans. 1841.)

Metschnikoff. Embryologie der doppelt-füssigen Myriapoden (Chilognatha). (Siebold and Kölliker's Zeitschrift. 1874.)

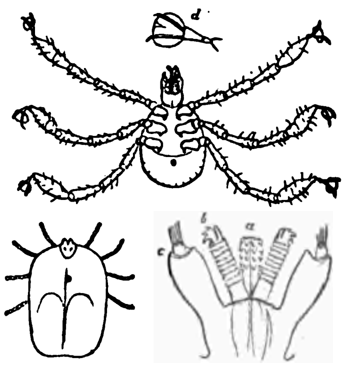
——. Embryologisches ueber Geophilus. (Siebold and Kölliker's Zeitschrift. 1875.)

Development of the Mites. Coming now to the mites and spiders, we find some peculiar features in the life-history of the former which deserve attention, though space compels us to be brief at the risk of being obscure. Most mites pass through a metamorphosis, some undergoing striking changes within the egg. For example, the *Atax Bonzi*, which is a parasite on the gills of fresh water muscles, first hatches in an oval form enveloped in a membrane (deutovum). From this "deutovum" is developed a six-footed larva. In this second larva state it is free, moving over the gills of the mussels, finally boring into the flesh of its host to undergo its next transformation. Here the young mite increases in size and becomes round. The tissues soften, the limbs are short and much larger than before, the animal assuming an embryo-like appearance, and moving about like a rounded mass in its enclosure. After a moult it assumes the so-called "pupa-state." During this process the limbs grow much shorter and are folded beneath the body, the animal being immovable, while the whole body assumes a broadly ovate form, and looks like an embryo just before hatching, but still lying within the egg.

In the genus Myobia, a parasite of the European field-mouse,

there is not only a "deutovum," but also what Claparède calls a "tritovum-stage," there being two stages with distinct embryonal membranes before the six-legged free larval state is assumed, the larva when hatching having thrown off two membranes, as well as the egg-shell. Certain bird-mites pass through four stages to reach the male condition, while the females pass through as many as five before attaining sexual maturity. Fig. 265 illustrates the six-legged larva of the tick, which is simply a large mite. The eggs of the mites either undergo total segmentation or a partial one, as in the spiders.

Fig. 265.



Tick and Six-legged Young.

The water-bears or Tardigrades are born with four pairs of legs, not undergoing any metamorphosis. Not so, however, with certain worm-like mites, which by their parasitic life lose all resemblance to other mites and are often mistaken for intestinal worms. I refer to the Pentastoma and Linguatula. Here the metamorphosis is backwards, the young after passing through a morula condition, being born as short, plump, oval mites, provided with boring horny jaws, but with only two short rudimentary legs.

Finally, we come to those problematical forms, the sea-spiders, or Pycnogonidæ, which are often referred to the Crustacea, whose development has been so faithfully studied by Dr. Dohrn. The yolk undergoes total segmentation, and the young are hatched with three pairs of legs, which after moulting attain in some species an extraordinary length.

To sum up, then, certain mites pass through either—

1. A Morula state, or the yolk only partially divides.
2. Sometimes one or two embryonal stages (deutovum and tritovum).
3. A six-legged larval state.
4. Eight-legged "pupal" state.
5. Adult.

LITERATURE.

Claparède. Studien an Acariden. (Siebold and Kölliker's Zeitschrift. 1868.)

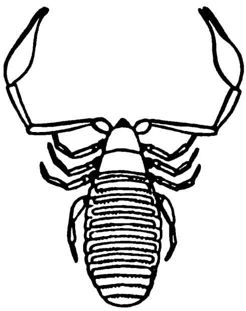
Leuckart. Bau und Entwickelungsgeschichte der Pentastomen. Leipzig und Heidelburg. 1860.

Dohrn. Untersuchungen ueber Bau und Entwicklung der Arthropoden. Heft. I. 1870.

Consult also papers by Dugès, Doyère, Müller, Van Beneden, Robin and others.

Development of the False-scorpions (Fig. 266). Some most unexpected features occur in the life-history of these little tailless scorpion-like creatures, which are found living under the bark of trees, and under stones, etc. The female runs about in early summer pressing the eggs to the under side of its body by means of its claws or nippers.

Fig. 266.



False-scorpion.

Here, as in most mites, the segmentation of the yolk is total. The blastoderm forms, and then a singular feature ensues, namely, the collection of an albuminous substance between the egg-shell and the blastoderm, increasing the size of the egg very materially and containing small bodies; suggesting an embryonal membrane, though Metschnikoff does not regard it as truly such. Soon the blastoderm becomes two-layered.

Next arise the rudiments of the two large claws, before any other limbs appear; at the same time a huge projection forms on the head, with indications of muscular bands. This strange appearance is merely a sort of temporary upper lip. At this time the end of the body is conical and curved beneath the abdomen. In this imperfect stage the embryo sheds a skin and then breaks through the delicate egg-membrane, becoming free, though the larva, kangaroo-like, is still attached to the under side of the mother Chelifer, where it remains until it has completed its metamorphoses, though of course it derives no nourishment from its mother.

Now the embryo-larva is nearly as long as broad, with the singular hood-like upper lip, and the rudiments of the first pair of feet directly behind the enormous rudimentary nippers. Within are no signs of a digestive sac or any other organs, simply a mass of yolk cells.

In the second larva-state the body is broader than long, the "upper lip" diminutive in size, and the mandibles and four pairs of legs are present. Here also, as in the scorpions and the spiders, four pairs of deciduous abdominal feet appear (such as our author has also seen in Phalangium and Forficula). There are now seven segments in the abdomen.

The larval skin is after a while ruptured, and the insect deserts its parent, in a form like that of the mature animal.

It will thus be seen that the first larva of Chelifer is comparable with that of certain low mites, but very different from the Scorpion, its nearest ally, the segmentation of the yolk being total, as in most mites, the sea spiders, Pentastoma and the Tardigrades, while the larval condition is on a still lower plane of existence than the Nauplius of the lower Crustacea. The false-scorpion differs much more from the spiders, the scorpion and other Pedipalps, than the harvest-man (Phalangium) Phrynus and the Acarina.

The harvest-men, or daddy-long-legs, as the researches of Metschnikoff and Balbiani show, develop as in the spiders, differing from them only in the want of a provisional post-abdomen and the relatively smaller abdomen.

The false-scorpions pass through, then:

1. A Morula stage.

2. Hatching in the first larval state, with but one pair of appendages (maxillæ).

3. Second larval state, with all the limbs present, but enveloped in a larval skin.

4. Throwing off the larval skin, becoming free and with the form of the adult animal.

LITERATURE.

Metschnikoff. Entwicklungsgeschichte des Chelifer. Siebold and Kölliker's Zeitschrift für wissens. Zoologie. Leipzig, 1871.)

Development of the Scorpions, etc. (Pedipalps). In a beautiful memoir by Metschnikoff on the embryology of the Scorpion we have full details regarding the embryonic life of this animal, which brings forth its young alive early in summer; being one of the very few viviparous insects known. His studies were made on three species of Scorpio found in southern Europe. The females are big with young at the end of spring or early in summer. I have observed this to be the case with the scorpion of the Florida Keys.

The earliest phases of development take place in the follicles of the ovary. The blastoderm is formed out of a few polar cells just as in the higher crustacea (Isopods and Decapods). It is at first a round disc, which eventually splits into two germ-layers. Soon

it becomes oval, the larger end being the head-end. The next step is the formation of a primitive longitudinal furrow, and afterwards of two transverse creases dividing the germ into three portions, the anterior the head, the middle portion the thorax and abdomen, and the third, the so-called post-abdomen.

The egg now leaves the follicle and descends into the oviduct. The head grows broader, and by this time the germ is subdivided into twelve segments, from which the appendages next bud out. The mouth may be discerned, the claws are indicated, the post-abdomen is folded on the body and the nerve-ganglia may be detected arising from the outer germ-layer. The embryo is now surrounded by a membrane composed of two layers of quite dissimilar cells.

A singular feature, also noticeable in other Insecta, is the presence of six pairs of deciduous abdominal feet, which directly assume the form of horizontal plates, with a terminal button, which finally disappear, the four pairs of stigmata taking their place; the second pair, however, become converted into the comb-like tracheal gills, so that it is evident that these are exvaginate stigmata. The germ (primitive band) is now broader, and the limbs have a more definite outline and are jointed, while the head is narrower than before, assuming the shape of that of the adult.

Metschnikoff claims that there are three germ-layers in the Scorpion, homologous with those of the vertebrates.

A summary of the chief events in the development of the scorpion is as follows:

1. Partial segmentation of the yolk, the embryo developing within the oviduct.

2. The young is brought forth by the mother, in a form exactly like the adult, and about half an inch long, about a dozen being produced in a season.

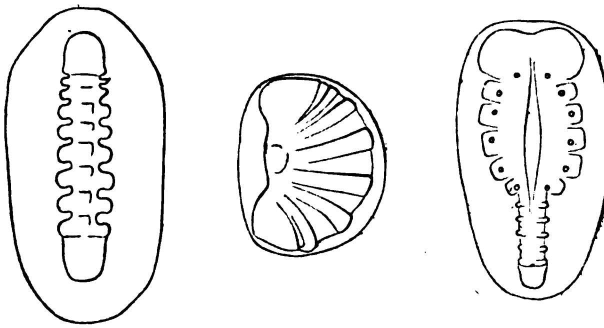
LITERATURE.

Rathke. Zur Morphologie. Reisebemerkungen aus Taurien. 1837.
Metschnikoff. Embryologie des Scorpions. (Siebold and Kölliker's Zeitschrift. 1870.)

Development of the Spider. From the life-history of one spider we may learn that of all, as there is much uniformity in the mode of development of all those species whose growth has been yet observed. The eggs are laid usually in silken cocoons. All undergo partial segmentation of the yolk, which is surrounded by

a blastoderm, which thickens on one side forming the primitive band, eventually becoming marked off into rings or zones, as in

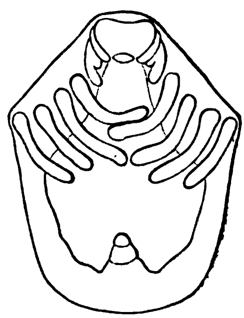
Fig. 267. Fig. 268. Fig. 269.



Development of the Spider. After Claparède.

Fig. 267. The primitive band elongates, new segments appear, (Fig. 268) until finally the germ appears when drawn as if spread out, as in Fig. 269. Besides the rudiments of the two pairs of head-appendages (*i.e.*, the mandibles and maxillæ) and the four pairs of legs, there are at first four, as in the figure, and subsequently six pairs of deciduous abdominal feet as in the Scorpion and two other species of tracheate insects.

Fig. 270.



Advanced embryo of the Spider.

Soon the mouth-parts and legs grow longer, and the embryo spider lies on the surface of the yolk as seen in Fig. 270. Finally, the head, originally distinct from the thorax, becomes soldered to the thorax; the eyes appear and the animal is rapidly perfected, the spider being hatched in a form like the adult, differing only in size and its paleness of color; the changes in after life being almost imperceptible. All spiders, then, so far as known:

1. Undergo in the egg state a partial segmentation of the yolk, and

2. Are hatched in the adult form, having no metamorphosis.

LITERATURE.

Herold. De Generatione Aranearum in Ovo. Marburg, 1824.
Claparède. Recherches sur l'Evolution des Araignées. Utrecht, 1862.

Development of the true Insect. While the history of the winged insects before hatching is much the same in the different orders, there are some exceptional modes of development possessing a high degree of interest on account of the resemblance to the mode of embryonic growth of still lower animals. First I will give an epitome of the changes observed by myself within the egg of a

Fig. 271.

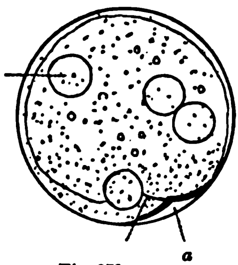


Fig. 272.

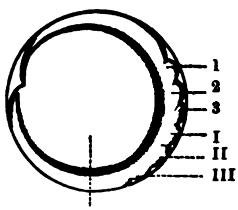


Fig. 273.

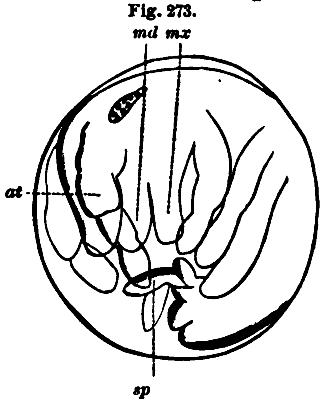
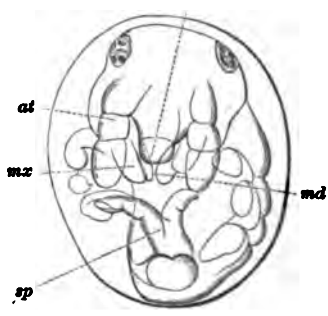


Fig. 274.

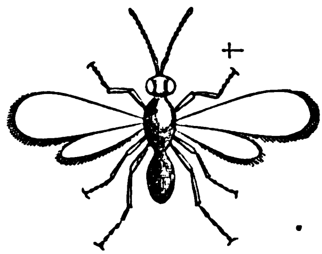


Development of a Poduran.

Poduran. The eggs were not studied until after the formation of the blastoderm, but Ulianin of Moscow has ascertained that the eggs of certain Podurids undergo total segmentation, in this feature, as indeed in some of the other phases of embryonic life, closely resembling the Myriopods. Fig. 271 shows the primitive band infolded at *a*, as in the Myriopod germ. A more advanced stage (Fig. 272) shows the rudimentary appendages (1–3, I–III) the

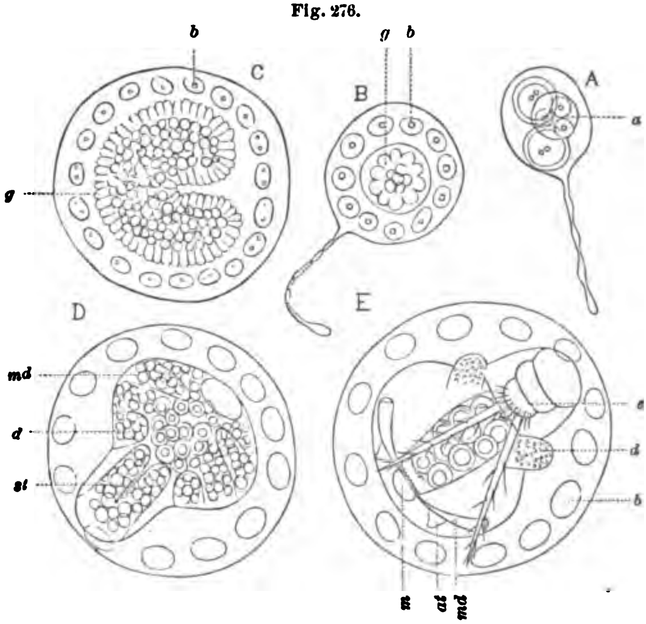
second maxillæ or labium, not being present. (It will be remembered that a pair of maxillæ are also wanting in the Thousand-legs.) The next change is the closure of the body-walls over the yolk, and the appearance of the rudiments of the "spring." By this time the serous membrane is formed, being a tough membrane enveloping the germ. In a succeeding stage the intestine is formed and the rudiments of th antennæ and legs have greatly increased in size. Still later, the appendages begin to show traces of joints. In a later period (Fig. 273, 274 *a*) the head is quite

Fig. 275.



Platygaster.

Fig. 276.



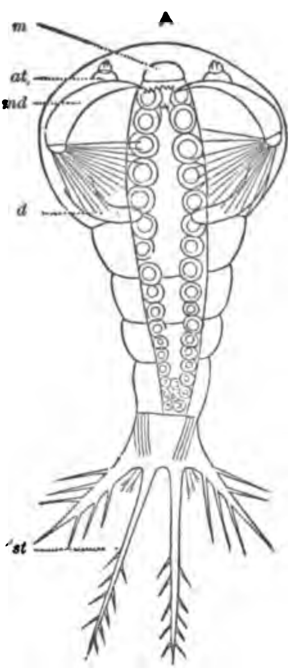
Development of Platygaster.

separate from the rest of the body, the antennæ (*at*) are of much the same shape as in the larva, while the upper lip (labrum) and clypeus are clearly indicated, and the spring (*sp*) is fully formed. Soon after, the "finishing touches" are, as it were, put on, and the mandibles and maxillæ (*md* and *mx*) are withdrawn within the

head, when the embryo throws off the chorion and serous membrane and runs about in a lively way.

Coming now to the true winged insects, we are met with a very exceptionable mode of development, observed by Ganin in certain species of minute ichneumon flies, some of them egg-parasites. The ovary of Platygaster (Fig. 275) differs from that of most other insects in that it is a closed tube or sac. Hence it follows that at every time an egg is laid, the egg-tube is ruptured. The egg is a single cell. Out of this cell (Fig. 276 *A*, *a*, arise two other cells, but the central cell (*a*) gives rise to the embryo, which as seen at *B*, *g*, originates from the nucleus of *A*, *a*, while the circle of cells, *b*, form an equivalent to the serous membrane or blastodermic skin of other insects and crustacea. The germ farther advanced, as in *C*, *g*, reminds us of the embryo of certain low worms. *D* and *E* are successive stages in the growth of the provisional larva (Fig. 277, *m*, mouth; *at*, antennæ; *md*, mandibles; *d*, deciduous organs). In this condition it clings to the inside of its host by means of its temporary hook-like jaws (*md*), moving about like a Cestodes embryo. The nerves, blood vessels and air tubes are wanting, while the alimentary canal is simply a blind sac, remaining in an unorganized state.

Fig. 277.



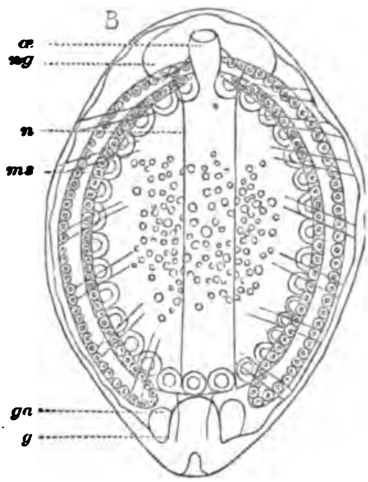
First larva of Platygaster.

It then passes into the second larval state (Fig. 278) like that of the ichneumon flies, and the remaining changes into the pupal and winged state are as usual.

In Polynema, the larva in its first stage is very small and motionless, and with scarcely a trace of organization, being a mere flask-shaped sac of cells. After five or six days it passes into a worm-like stage, and subsequently into a third stage (Fig. 279, *tg*, three pairs of abdominal tubercles destined to form the ovipositer; *l*, rudiments of the legs; *fk*, portion of the fatty body; *at*, rudi-

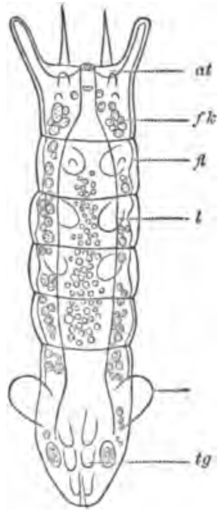
ments of the antennæ; *fl*, imaginal disks or rudiments of the wings).

Fig. 278.



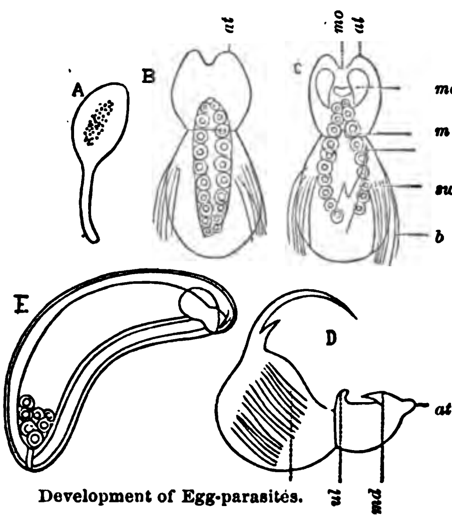
Second larva of Platygaster.

Fig. 279.



Third larva of Polynema.

Fig. 280.



Development of Egg-parasites.

The larva of Ophioneurus is at first of the form indicated by Fig. 280, *E*. It differs from those genera already mentioned, in

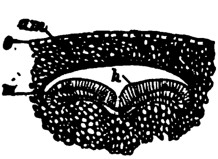
remaining within its egg-membrane, and not assuming their strange forms. From the non-segmented, sac-like larva it passes directly into the pupa state.

The development of Teleas is like that of Platygaster. Fig. 280, *A*, represents the egg; *B*, *C* and *D*, the first stage of the larva, the abdomen being furnished with a series of bristles on each side. *B* represents a ventral, *C* a dorsal, and *D* a profile view; *at*, antennæ; *md*, mandibles; *mo*, mouth; *b*, bristles; *m*, intestine; *sw* the tail, and *ul* the under lip or labium. Not until the beginning of the second larval stage is the primitive band formed.

In all the other insects whose early stages have been studied, there is a remarkable uniformity, all travelling nearly the same developmental road until just before hatching, when they assume the characteristics belonging to the larval forms of their respective orders. For example not until very late in embryonic life do the germs of a bee, a bug, a beetle or a fly, or even a dragon fly, differ in any essential point.

We will, then, give a general and brief account of the mode of growth of the germ, not dwelling on the metamorphoses of insects. The egg after fertilization shows the first sign of the new life thus originated by the appearance of a few polar cells; these multiply and surround the egg with a single layer, thus forming the blastoderm. The segmentation of the yolk is thus peripheral and partial. On one side of the egg the blastodermic cells elongate, forming a thickening, called the primitive streak or band, which in some insects sinks into the yolk. By this time the serous membrane (*s*) has moulted and envelopes the germ and yolk. The germ soon splits into an outer (ectoderm) and inner layer (endoderm) and then sheds the true amnion, which as in vertebrates, peals off from the primitive band or germ, and acts as a protective membrane.

Fig. 281.

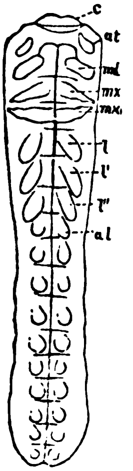


Section of Sphinx Embryo.

In Fig. 281 (after Kowalevsky) representing a transverse section of the embryo of a Sphinx, we see the relation of parts. The primitive band has sunk into the yolk which is surrounded by the serous membrane (*s*) or blastodermic skin (formerly, but erroneously termed the amnion). The primitive band is seen to be formed of two layers, *h*, the outer, and *m*, the inner. In the

outer is subsequently formed the nervous cord and air vessels, while from the inner arise the digestive canal and its glands and the organs of circulation. The amnion (*am*) envelopes the germ. From the ventral side of the primitive band bud forth the appendages of the head, the thorax, and as in the embryo caterpillar, the ten pairs of abdominal legs, *i.e.*, one to each ring, a portion of which disappear before it hatches, no caterpillar having more than five pairs of prop-legs. Fig. 282 (after Kowalevsky) represents the primitive band of the Sphinx, with the four pairs of head appendages (*c*, upper lip; *at*, antennæ; *md*, mandibles; *mx*, *mx'* first and second maxillæ), and the three pairs of thoracic legs (*l*, *l' l''*) succeeded by the ten pairs of abdominal legs. The observer will notice that all the appendages, whether of the head or thorax or hind-body, are alike at first, being simple outgrowths of the outer germ-layer.

Fig. 282.



Sphinx embryo.

When in a more advanced stage, as seen in the accompanying figure (283, *am*, serous membrane; *db*, amnion; *vk*, forehead) of the embryo louse, the antennæ are longer than the mouth-parts, and the legs are still larger. After this those features characterizing the different orders of insects appear, and shortly before hatching we can ascertain to what group the embryo belongs.

Fig. 283.

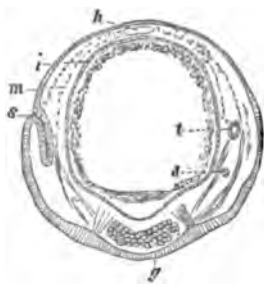
Embryo of the Louse.

As regards the development of the internal organs, the nervous system is the first to show itself, the alimentary canal is next formed, and the stigmata and air-tubes arise as invaginations of the outer germ-layer. The development of the salivary glands precedes that of the urinary tubes, which, with the genital glands are offshoots of the primitive digestive tract. Finally the dorsal vessel is formed. Fig. 284 (after Kowalevsky) is a transverse section of the embryo bee; *g*, is the nerve ganglia; *i*, the alimentary canal; *m*, muscular bands running to the heart (*h*);

d is a gland, and *t*, indicates the trachea, its mode of origin being illustrated on the left side of the figure where it is seen in communication with a stigma or air-hole (*s*).

So far as we know (the Thysanura and certain minute ichneumons excepted) there is in the winged insects a remarkable uniformity in their mode of development, and it is difficult to determine what embryological characters may be set down as distinguishing even the different orders, but they will probably be found, if anywhere in the form of the advanced embryos.

Fig. 284.



Section of advanced Sphinx embryo.

A summary of the most important events in the life-history of insects is as follows:

1. Peripheral (partial) segmentation of the yolk (in the Poduræ a true Morula condition).

2. Larva hatched in the form of the adult, but (in Aphis and Miastor producing young alive) wingless, and undergoing an incomplete or complete metamorphosis.

3. Pupa state, more or less marked (in one species of Chironomus producing young).

4. Adult, usually winged, sometimes propagating asexually.

LITERATURE.

Herold. Disquisitiones de Animalium vertebris carentium in Ovo Formatione. Frankfurt a Maine. 1835–38.

Kölliker. Observationes de prima Insectorum Genesi. Turici, 1842.

Zaddach. Untersuchung ueber die Entwickelung und den Bau der Gliederthiere. Berlin, 1854.

Leuckart. Die Fortpflanzung und Entwickelung der Pupiparen nach Beobachtungen an Melophagus ovinus. Halle, 1858.

Huxley. On the Agamic Reproduction and Morphology of Aphis. (Phil. Trans. London, 1859.)

Weissmann. Die Entwickelung der Dipteren im Ei. (Siebold and Kölliker's Zeitschrift, xiii, 1864.)

Metschnikoff. Embryologische Studien an Insecten. (Siebold and Kölliker's Zeitschrift. 1866.)

Melnikow. Beitrage zur Embryonalentwicklung der Insekten. (Archiv für Naturgeschichte, 1869.

Brandt. Beitrage zur Entwicklungsgeschichte der Libelluliden und Hemipteren, etc. (Mémoires Acad. Imp. St. Petersburg, 1869.)

Ganin. Ueber die Embryonalhulle der Hymenopteren und Lepidopteren Embryonen. (Mémoires Acad. Imp. St. Petersburg, 1869.)

——. Beitrage zur Erkenntniss der Entwickelungsgeschichte bei dem Insekten. (Siebold and Kölliker's Zeitschrift, 1869.)

REVIEWS AND BOOK NOTICES.

TENNEY'S ELEMENTS OF ZOOLOGY.*—This is a profusely illustrated book, of convenient size and well adapted by its simple style for instruction in schools. It is a decided improvement in matter and illustration on the "Manual of Zoology" by the same author, as more attention is bestowed to anatomy and histology; this portion being illustrated by well selected engravings, mostly taken from Milne-Edward's "Zoology."

MICROSCOPY.

THE "REFLEX ILLUMINATOR" FOR DIRECT ILLUMINATION.—Mr. Samuel Wells, of Boston, communicates to the "Cincinnati Medical News," his experience with Mr. Wenham's last illuminator, used upon transparent objects with transmitted light. Of course to obtain the direct effect the object must be mounted in balsam or other highly refractive medium, and the illuminator connected with the slide with glycerine or otherwise. The lens must be an immersion, and over 82° of working angular aperture, since nothing under 41° of semi-aperture can be lighted by this arrangement. Mr. Wells, among a large number of lenses, found only four capable of working with light at this angle,—a Powell & Lealand $\frac{1}{16}$, Tolles' $\frac{1}{10}$, and Tolles' four system $\frac{1}{6}$ and $\frac{1}{10}$. All these are famous resolving lenses, and their performance with this light is described as remarkably beautiful. An exactly similar use of the Wenham Paraboloid has been a favorite method of high-power illumination (differing only in angle and in not being limited to an unilateral effect) and gives the same exquisite definition with a perfectly corrected objective, though failing entirely with many objectives that are called first class.

RELIABILITY OF THE MICROSCOPE.—Mr. John Michels paper in "Popular Science Monthly," on the Microscope and its Misinterpretations, mainly by virtue of its title, largely contributes to an exaggerated popular estimate of the general untruthfulness of microscope teachings. The paper itself is a good popular synopsis of the Podura scale controversy, but has about the same rela-

* Elements of Zoology. A Text Book. By Prof. Sanborn Tenney. Illustrated by 750 wood engravings. New York: Scribner, Armstrong & Co. 1875.

tion to the general credibility of microscopical science that a dispute about some confessedly difficult double star would have to the science of astronomy. Experience is suggested as a safeguard, and so are high powers, which are of undisputed value notwithstanding that they chiefly, if not only, are liable to serious danger of misinterpretation. The necessity of corroboration of results in important cases by different observers is urged, to which the editor of the "Technologist" adds that varied methods of preparation are a stronger confirmation than a number of observers.

A CONCENTRATED METHOD OF MOUNTING.—Mr. C. H. Robinson, of Cleaveland, contributes to the "Postal Micro-cabinet Club," a slide illustrating a method of mounting where the space under a single large cover-glass is occupied by a considerable number of small circles with an object in each. He makes the circles of white zinc varnish, and sometimes adds a circle to the edge of the cover-glass as a finish. This method of mounting, the appearance of which is decidedly handsome, is particularly applicable to displaying several varieties of one species (as of selected diatoms or of foraminifera) on one slide, or to presenting in contrast different methods of preparing the same species.

NOTES.

WE noticed, in our last, that an Ohio State Association of Archæologists had been formed, and we now have to record the organization of similar State Associations in Indiana and Tennessee. These State Associations will be of great benefit if they result in the establishment of permanent museums of Archæology at the several capitals and foster careful research. It is also greatly to be hoped that they will take action at once in relation to the preservation of some of the most important of the ancient earthworks of the west and south.

IMPORTANT ANNOUNCEMENT!

Arrangements have been made by which Messrs. H. O. Houghton & Co., will become the publishers of the *American Naturalist*, beginning with Vol. X, 1876. Farther announcements will be made in our next number. Subscriptions for Volume X should accordingly be sent to H. O. Houghton & Co., Boston, Mass.

THE

AMERICAN NATURALIST.

Vol. IX.—DECEMBER, 1875.—No. 12.

ODONTORNITHES, OR BIRDS WITH TEETH.[1]

BY PROFESSOR O. C. MARSH.

REMAINS of birds are among the rarest of fossils, and few have been discovered except in the more recent formations. With the exception of *Archæopteryx* from the Jurassic, and a single species from the Cretaceous, no birds are known in the old world below the Tertiary. In this country numerous remains of birds have been found in the Cretaceous, but there is no satisfactory evidence of their existence in any older formation, the three-toed footprints of the Triassic being probably all made by Dinosaurian reptiles.

The Museum of Yale College contains a large series of remains of birds from the Cretaceous deposits of the Atlantic coast and the Rocky Mountain region, thirteen species of which have already been described by the writer. The most important of these remains, so far as now known, are the *Odontornithes*, or birds with teeth, and it is the object of the present communication to give some of the more marked characters of this group, reserving the full description for a memoir now in course of preparation.

The first species of birds in which teeth were detected was *Ichthyornis dispar* Marsh, described in 1872.[2] Fortunately the type specimen of this remarkable species was in excellent preservation, and the more important portions of both the skull and

[1] Published in part in the American Journal of Science, Vol. x, November, 1875.
[2] American Journal of Science, Vol. iv, p. 344, and vol. v, p. 74.

skeleton were secured. These remains indicate an aquatic bird, fully adult, and about as large as a pigeon.

The skull is of moderate size, and the eyes were placed well forward. The lower jaws are long, rather slender, and the rami were not coössified at the symphysis. In each lower jaw there are twenty-one distinct sockets, and the series extends over the entire upper margin of the dentary bone (Plate II, figures 1 and 2). The teeth in these sockets are small, compressed and pointed, and all are directed more or less backward. The crowns are covered with nearly smooth enamel. The maxillary teeth appear to have been numerous, and essentially the same as those in the mandible. Whether the premaxillary bones supported teeth, or were covered with a horny beak, cannot be determined from the present specimen.

The scapular arch and the bones of the wings and legs all conform closely to the true avian type. The sternum has a prominent keel, and elongated grooves for the expanded coracoids. The wings were very large in proportion to the legs, and the humerus had an extended radial crest. The metacarpals are coössified, as in recent birds, thus differing widely from those of *Archæopteryx*. The bones of the posterior extremities are slender, and resemble those of some aquatic birds. The centra of the vertebræ are all biconcave, the concavities at each end being distinct, and nearly equal (Plate II, figures 3 and 4). The sacrum is elongated, and made up of a large number of coössified vertebræ. Whether the tail was elongated or not cannot at present be decided.

The jaws and teeth of this species show it to have been carnivorous, and it was probably aquatic. Its powerful wings indicate that it was capable of prolonged flight.

Another Cretaceous bird (*Apatornis celer* Marsh), belonging apparently to the same order as *Ichthyornis*, was found by the writer in 1872 in the same geological horizon in Kansas. The remains preserved indicate an individual about the same size as *Ichthyornis dispar*, but of more slender proportions. The vertebræ are biconcave, and there were probably teeth.

The most interesting bird with teeth yet discovered is perhaps *Hesperornis regalis*, a gigantic diver, also from the Cretaceous of Kansas, and discovered by the writer in 1870. The type specimen, which was found by the writer in 1871, and described soon after,

consisted mainly of vertebræ and the nearly complete posterior limbs, all in excellent preservation.[1]

A nearly perfect skeleton of this species was obtained in Western Kansas by Mr. T. H. Russell and the writer in November, 1872, during the explorations of the Yale College party, and several other less perfect specimens have since been secured, and are now in the Yale Museum. These various remains apparently all belong to one species.

The skull of *Hesperornis* has the same general form as that in *Colymbus torquatus* Brün., but there is a more prominent median crest between the orbits, and the beak is less pointed. The brain cavity was quite small. The maxillary bones are massive, and have throughout their length a deep inferior groove which was thickly set with sharp, pointed teeth. These teeth had no true sockets, but between their bases there are slight projections from the sides of the grooves. (Plate III, figure 2). The teeth have pointed crowns, covered with enamel, and supported on stout fangs. (Plate III, figure 1*a*). In form of crown and base, they most resemble the teeth of Mosasauroid reptiles. The method of replacement, also, was the same, as some of the teeth preserved have the crowns of the successional teeth implanted in cavities in their fangs. The maxillary grooves do not extend into the premaxillaries, and the latter do not appear to have supported teeth. The external appearance, moreover, of the premaxillaries seems to indicate that these bones were covered with a horny bill, as in modern birds.

The lower jaws are long, and slender, and the rami were united in front only by cartilage. The dentary bone has a deep groove throughout its entire length, and in this, teeth were thickly planted, as in the jaws of *Ichthyosaurus*. The lower teeth are similar to those above, and all were more or less recurved (Plate III, fig. 2).

The scapular arch of *Hesperornis* presents many features of interest. The sternum is thin and weak, and *entirely without a keel*. In front, it resembles the sternum of *Apteryx*, but there are two very deep posterior emarginations, as in the Penguins. The scapula and coracoid are very small. The wing bones are diminutive, and the wings were rudimentary, and useless as organs of either flight or swimming.

The vertebræ in the cervical and dorsal regions are of the true

[1] American Journal of Science, iii, 360, May, 1872.

ornithic type, the articular faces of the centra being quite as in modern birds (Plate III, figures 3 and 4). The sacrum is elongated, and resembles that in recent diving birds. The last sacral vertebra is quite small. The caudal vertebræ, which are about twelve in number, are very peculiar, and indicate a structure not before seen in birds. The anterior caudals are short, with high neural spines and moderate transverse processes. The middle and posterior caudals have very long and horizontally expanded transverse processes, which restrict lateral motion, but clearly indicate that the tail was moved vertically, probably in diving. The last three or four caudal vertebræ are firmly coössified, forming a flat terminal mass, analogous to, but quite unlike, the "ploughshare" bone of modern birds. The anterior two at least of these caudals have expanded transverse processes.

The pelvic bones, although avian in type, are peculiar, and present some well marked reptilian features. A resemblance to the corresponding bones of a Cassowary is at once evident, especially in a side view, as the ilium, ischium, and pubis all have their posterior extremities separate. The two latter are slender, and also free, back of their union with the ilium at the acetabulum. The ischium is spatulate at its distal end, and the pubis rodlike. The acetabulum differs from that in all known birds, in being closed internally by bone, except a foramen, that perforates the inner wall.

The femur is unusually short and stout, much flattened anteroposteriorly, and the shaft curved forward. It somewhat resembles in form the femur of *Colymbus torquatus* Brün., but the great trochanter is proportionally much less developed in a fore-and-aft direction, and the shaft is much more flattened. The tibia is straight and elongated. Its proximal end has a moderately developed cnemial process, with an obtuse apex. The epi-cnemial ridge is prominent, and continued distally about one-half the length of the shaft. The distal end of the tibia has on its anterior face no ossified supratendinal bridge, differing in this respect from nearly all known aquatic birds. The fibula is well developed, and resembles that of the Divers. The patella is large, as in *Podiceps*, and in position extends far above the elevated rotular process of the tibia.

The tarso-metatarsal bone is much compressed transversely, and resembles in its main features that of *Colymbus*. On its anterior

face there is a deep groove between the third and fourth metatarsal elements, bounded on its outer margin by a prominent rounded ridge, which expands distally into the free articular end of the fourth metatarsal. This extremity projects far beyond the other two, and is double the size of either, thus showing a marked difference from any known recent or fossil bird. There is a shallow groove, also, between the second and third metatarsals. The second metatarsal is much shorter than the third or fourth, and its trochlear end resembles in shape and size that of the former. The existence of a hallux is indicated by an elongated oval indentation on the inner margin above the articular face of the second metatarsal. The free extremities of the metatarsals have the same oblique arrangement as in the *Colymbidæ*, to facilitate the forward stroke of the foot through the water. There are no canals or even grooves for tendons on the posterior face of the proximal end, as in the Divers and most other birds; but below this, there is broad, shallow depression, extending rather more than half way to the distal extremity.

The phalanges are shorter than in most swimming birds. Those of the large, external toe are very peculiar, although an approach to the same structure is seen in the genus *Podiceps*. On the outer, inferior margin, they are all deeply excavated. The first, second, and third have, at their distal ends, a single, oblique, articular face on the inner half of the extremity, and the outer portion is produced into an elongated, obtuse process, which fits into a corresponding cavity in the adjoining phalanx. This peculiar articulation prevents flexion except in one direction, and greatly increases the strength of the joints. The terminal phalanx of this toe was much compressed. The third, or middle toe, was greatly inferior to the fourth in size, and had slender, compressed phalanges, which correspond essentially in their main features with those of modern Divers.

The remains preserved of *Hesperornis regalis* show that this species was larger than any known aquatic bird. All the specimens discovered are in the Yale College Museum, and agree essentially in size, the length from the apex of the bill to the end of the toes being between five and six feet. The habits of this gigantic bird are clearly indicated in the skeleton, almost every part of which has now been found. The rudimentary wings prove that flight was impossible, while the powerful swimming legs and feet

were peculiarly adapted to rapid motion through the water. The tail appears to have been much expanded horizontally, as in the Beaver, and doubtless was an efficient aid in diving, perhaps compensating in part for want of wings, which the Penguins use with so much effect in swimming under water. That *Hesperornis* was carnivorous is clearly proven by its teeth; and its food was probably fishes.

The zoological position of *Hesperornis* is evidently in the *Odontornithes;* but the insertion of the teeth in grooves, the absence of a keel on the sternum, and the wide difference in the vertebræ require that it be placed in a distinct order, which may be called *Odontolcæ*, in allusion to the position of the teeth in grooves.

The two orders of birds with teeth would then be distinguished as follows:—

Sub-Class, ODONTORNITHES (or AVES DENTATÆ).

A. Teeth in sockets. Vertebræ biconcave. Sternum with keel. Wings well developed.

Order, ODONTOTORMÆ.[1]

B. Teeth in grooves. Vertebræ as in recent birds. Sternum without keel. Wings rudimentary.

Order, ODONTOLCÆ.

In comparing *Ichthyornis* and *Hesperornis*, it will be noticed that the combination of characters in each is very remarkable, and quite the reverse of what would naturally be expected. The former has teeth in distinct sockets, with biconcave vertebræ; while the latter has teeth in grooves, and yet vertebræ similar to those of modern birds. In point of size, and means of locomotion, the two present the most marked contrast. The fact that two birds, so entirely different, living together during the Cretaceous, should have been recovered in such perfect preservation, suggests what we may yet hope to learn of life in that period.

The geological horizon of all the *Odontornithes* now known is the Upper Cretaceous. The associated vertebrate fossils are mainly Mosasauroid reptiles and Pterodactyls.

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[1] The name *Ichthyornithes*, first proposed for this order by the writer, proves to be preoccupied, and *Odontotormæ* may be substituted. The name *Ichthyornidæ* may be retained for the family.—O. C. M.

Explanation of Plates.

Plate II.—*Ichthyornis dispar* Marsh. Twice natural size.

Figure 1. Left lower jaw; side view.
Figure 2. Left lower jaw; top view.
Figure 3. Cervical vertebra; side view.
Figure 4. Same vertebra; front view.

Plate III.—*Hesperornis regalis* Marsh.

Figure 1. Left lower jaw; side view; half natural size.
Figure 1*a*. Tooth; four times natural size.
Figure 2. Left lower jaw; top view; half natural size.
Figure 3. Dorsal vertebra; side view; natural size.
Figure 4. Same vertebra; front view; natural size.

MODE OF GROWTH OF THE LOWER VERTEBRATES.

BY A. S. PACKARD, JR.

In the adult Amphioxus, we behold a vertebrate without a true back bone, but a dorsal cord like that of certain larval Ascidians; with no brain, no true heart, but with a vascular system resembling that of worms; with primitive kidneys like the segmental organs of worms, and with the front end of the alimentary canal perforated with gill-slits, like those of Ascidians and the Balanoglossus worm rather than vertebrates. Viewing the body externally, it has no true head as in fishes, nor appendages supported by bony axes, like the fins and arms or legs of vertebrates. Yet on making a section of the body, the relation of the chief anatomical organs is on the vertebrate plan, a nerve-cavity being situated above the digestive cavity, the vicarious back bone, or *chorda dorsalis*, separating the two cavities.

Development of Amphioxus. Again when we study the development of Amphioxus, we shall find, that while there are important points in which the embryology of this animal differs much from that of the higher vertebrates; still, as observed by Balfour, "all the modes of development found in the higher vertebrates are to be looked upon as modifications of that of Amphioxus."

For the life-history of the lancelet, we turn to Kowalevsky's classical memoir. He found the eggs issuing in May from the mouth of the female, and fertilized by spermatic particles likewise pouring out from the mouth of the male. The eggs are very small, 0.105 millimetres in diameter. The eggs undergo total segmentation, exactly as in the sponge, the ascidian, the mammal, and even as in man, and leaving a segmentation cavity which becomes the body-cavity.

The blastoderm now invaginates and the embryo swims about as a ciliated gastrula, comparable with that of the sponge, or Sagitta (Fig. 179). The body is now oval, and the germ does not differ much in appearance from a worm, starfish, snail or ascidian in the same stage of growth. No vertebrate features are yet developed.

Soon the lively ciliated gastrula elongates, the alimentary tube arises from the primitive gastrula-cavity, while the edges of the

flattened side of the body grow up as ridges which afterwards, as in all vertebrate embryos, grow over and enclose the spinal cord. By this time the transverse muscular bands appear.

By the time the embryo is twenty-four hours old it assumes the form of a ciliated flattened cylinder, with both ends much alike. It is now somewhat like the Ascidian embryo (Fig. 217, *B*, *n*), there being a nerve-cavity, the nerve-tube, with an external opening, which afterwards closes.

The vertebrate character, namely, the embryonic back bone (*chorda dorsalis*) has now appeared, and extends to the front end, beyond the end of the brain, instead of being confined to the posterior portion of the body as in the Ascidians (Fig. 217, *B*, *x*).

In the next stage observed by the Russian embryologist, the Amphioxus-form was attained, the body being compressed and deeper in the region of the mouth, though there is no true head. The first gill-opening now appears, the mouth having previously been formed, and afterwards twelve such openings appear; the pharynx is thus provided with ciliated slits, as in the ascidians, the Balanoglossus; and, on the other hand, all embryo vertebrates. The embryo lancelet is still ciliated, but these swimming-hairs disappear eventually and the young animal seeks the bottom and burrows finally in the sand. When the larval Amphioxus is still very small, the body is not symmetrical, the mouth is far on one side, and on the lower edge is a circle of external filaments surrounding the mouth, comparable with those of the ascidians, the clam or certain worms.

It seems to result from these and other facts, not here presented, that while the Amphioxus is a low, embryonic vertebrate, which graduates into the fishes through the lamprey and myxine, the early history of Amphioxus unmistakably points back to worm-like parents; and on the other hand that of the vertebrates indicates their descent from an Amphioxus-like ancestor.

Briefly recapitulating the chief events in the life of the lancelet, we find the following well marked stages:

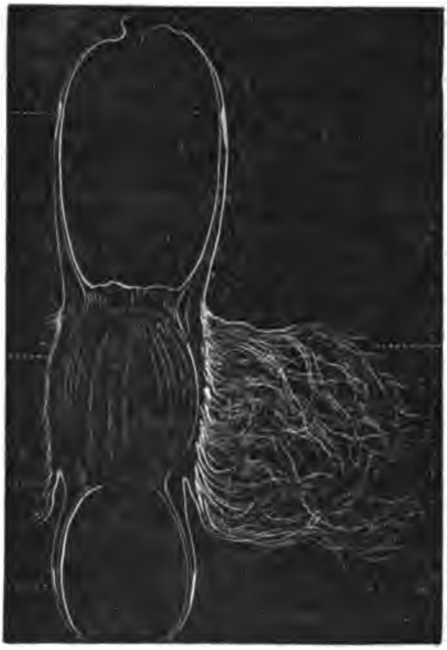
1. Morula.
2. Gastrula (ciliated).
3. Ascidian-like larva.
4. Adult.

LITERATURE.

Kowalevsky. Entwickelungsgeschichte des Amphioxus lanceolatus. (Memoires de l'Acad. Imp. des Sciences de St. Petersbourg, 1867).

Development of the Sharks and Skates (*Selachians*). These fishes are either oviparous or viviparous. The dog-fish brings forth her young alive, while the skates and many sharks lay square eggs like those of the skate (Fig. 285, after Wyman), each corner sending out a tendril by which it is attached to sea-weeds. The yolk is not enclosed in any membrane like the vitelline membrane of birds, but lies freely in a viscid albumen filling the egg-capsule (Balfour).

Fig. 285.

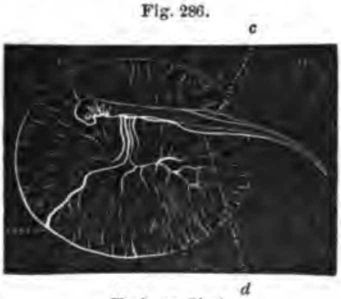


Egg of the Skate.

We will now, in order to make out a tolerably complete life-history of a Selachian, condense Balfour's account of the early stages of the dog-fish (Mustelus), and close with the latter stages of the skate, as given by the late Professor Wyman. The blastoderm or germinal disk is a large round spot darker than the rest of the yolk and marked off from the rest of the yolk by a dark line (really a shallow groove). Segmentation occurs much as described in the bony fishes, reptiles and birds. The upper germ-layer (epiblast) arises much as in the bony fishes, the Batrachians and birds, while the two inner germ-layers are not clearly indicated until a considerably later stage. The segmentation-cavity is formed much as in the bony fishes. There is no invagination of the outer germ-layer to form the primitive digestive cavity and anus of Rusconi, as in Amphioxus, the Lamprey, sturgeon and Batrachians, but the Selachians agree with the bony fishes, the reptiles and birds, in having the alimentary canal formed by an infolding of the innermost germ-layer, and with no anus of Rusconi, the digestive canal remaining

in communication with the yolk for the greater part of embryonic life by an umbilical canal. This mode of origin of the digestive cavity, Balfour regards as secondary and adaptive, no "gastrula" (Hæckel) being formed as in Amphioxus, etc. The embryo now rises up as a distinct body from the blastoderm, just as in other vertebrates, and there is a medullary groove along the middle line, and by the time this has appeared the middle and inner germ-layers are closely indicated. And now development goes on much as in the chick.

Fig. 286.



Embryo Skate.

At this time the embryo dog-fish externally resembles the young trout; the chief difference is an internal one, the outer germ-layer not being divided into a nervous and epidermal sub-layer as in the bony fishes.

The next external change is the division of the tail-end into two caudal lobes. The notochord arises as a rod-like thickening of the third germ-layer, from which it afterwards entirely separates, so that the germ, if cut transversely, would appear somewhat as in the embryo bird (Fig. 304).

Fig. 287.

More advanced Embryo Skate.

Fig. 288.

Side view of head of Fig. 287.

Now the protovertebræ arise, and about this time the throat becomes a closed tube. The head is now formed by a singular flattening-out of the germ, like a spatula, while the medullary groove is at first entirely absent. The brain then forms, with its three divisions into a fore, middle and hind brain. Soon about twenty primitive vertebræ arise, and by this time the embryo is very similar, in external form, to any other vertebrate embryo, and finally hatches in the form of the adult.

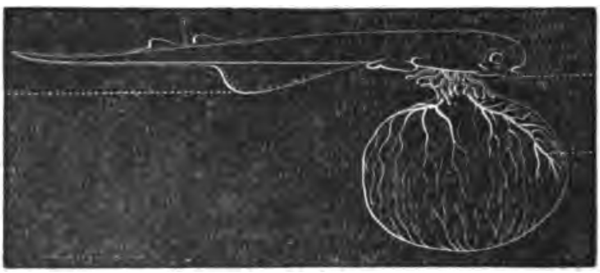
Not so, however, with the skate (*Raia batis*) as it presents an additional chapter in its life-history, discovered by Professor Wyman. Fig. 286 (this and those following after Wyman) shows the young skate resting on the large yolk-sac. It is eel-shaped, the dorsal (*c*) and (*d*) anal fins extending to the end of the tail as in the eel. Fig. 287 represents a more advanced embryo, showing at *a* and *b* the pectoral and ventral fins, and at *d*, the temporary anal. Fig. 288 is a side view of the same enlarged (*a*, first branchial fissure, largest at its outer end; this enlarged portion corresponds with the future spiracle; *b*, the inner end; the first arch is in front of the fissure; *b'*, the second fissure, in front of which is the second arch, bearing a fringe; *c*, nasal fossa; *d*, projection of the optic lobes; *e*, cerebral lobes.)

Fig. 289.

Shark-shaped embryo Skate.

Soon after the embryo skate becomes shark-shaped, as in Fig. 289, while Figs. 290 and 291, represent a lateral and dorsal view of the embryo (*b*, facial disk; *a*, pectoral; *c*, ventral fin; *e*, gill-fringes). There are at first seven branchial fissures, the most anterior of which is converted into the spiracle, which is the homologue of the Eustachian tube and the outer ear-canal; the seventh is wholly closed up, no trace remaining, while the five others remain permanently open.

Fig. 290.



More advanced embryo of Skate.

Fig. 292 represents the newly hatched skate, when the form of the adult is closely approached (*a*, yolk-sac in the cavity of the

abdomen, connecting with the intestine, *b*; *c*, embryonic portion of the tail which disappears in the adult (Wyman).

A condensed summary of the chief events in the life of a Selachian, is as follows:—

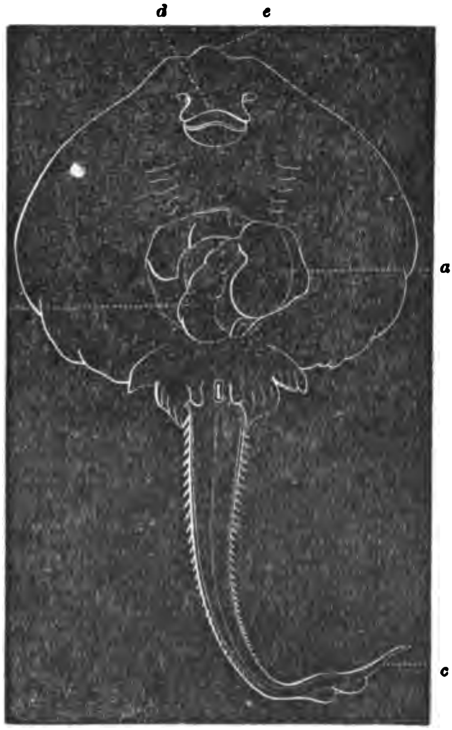
1. Partial segmentation of the germinal disk.

2. The embryo arises as a distinct body from the germinal disk (the "gastrula"-condition being suppressed).

Fig. 291.

Dorsal view of Fig. 290.

Fig. 292.



Newly-hatched Skate.

3. The embryo appears like that of any other vertebrate, until finally

4. The shark or skate form is assumed just before birth, or hatching from the egg.

5. The skates pass through a shark-like form, before attaining the adult shape.

LITERATURE.

Wyman. Observations on the Development of *Raia batis*. (Memoirs Amer. Acad.

Bambeke. Recherches sur le Developpment du *Pelobates fuscus* (Mémoires couronnés Acad. Belgique, 34, 1870.)

Balfour. A preliminary Account of the Development of the Elasmobranch Fishes. (Quart. Jour. Micr. Science, 1874.)

Development of the bony Fishes. During their reproductive season, the bony fishes, such as the strikleback, salmon and pike, are more highly colored than at other times, the males being especially brilliant in their hues, while other secondary sexual characters are developed. The female deposits her eggs either in masses at the surface of the water, as in the cod and goose fish, or at the bottom on gravel or sand as in most other fishes, the male passing over them and depositing his "milt" or spermatic

Fig. 293.

The same as Figs. 294, 295, 296, before the egg-shell has burst.

Fig. 294.

Embryo Blenny seen in front.

Fig. 295.

The same as Fig. 294, seen in profile from the right side.

Fig. 296.

The same as Fig. 294, seen in profile from the left side.

particles. The egg has a thin transparent shell, and the yolk is small, covered with a thick layer of the "white."

The eggs after fertilization undergo partial segmentation, the primitive streak, notochord, nervous cord and brain developing much as described in the section on the embryology of birds. That the embryo before us is a fish is soon determined by the absence of an amnion and allantois, and by the fact that the germ lies free over the yolk like a band. Figs. 293, 294, 295, 296 (cop-

ied by Agassiz [1] from Rathke), represent an advanced stage of the embryo Blenny (*Zoarces viviparus*) in various positions, with the eyes, gill arches, fins and vitelline network of blood vessels on the outer surface of the yolk sac.

In the pike the heart begins to beat about the seventh day, and by this time the alimentary canal is marked out. The primitive kidneys are developed above the liver. The air-bladder (probably the homologue of the lungs of higher vertebrates) arises as an offshoot opposite the liver from the alimentary canal, and the gall-bladder is also originally a diverticulum of the intestine. The urinary bladder in the fish is supposed to be the homologue of the allantois of the higher vertebrates. The principal external change is the appearance of the usually large pectoral fins.

The embryo pike hatches in about twelve days after development begins and swims about with the large yolk bag attached, and it is some seven or eight days before the young fish takes food, living meanwhile on the yolk mass. The perch hatches in twelve days after the egg is fertilized, and swims about for eight or ten days before the yolk is absorbed. The vent opens in the pike four days, and in the perch six days, after hatching. The gills gradually develop as the yolk is absorbed.

The tail in most bony fishes (the Gadidæ excepted, according to Owen), is heterocercal as in the maturer sharks, but subsequently after the fish has swam about for a while and increased in size it becomes homocercal or symmetrical. The scales are the last to be developed.

In the large size of the pectoral fins, the position of the mouth, which is situated far back under the head, the heterocercal tail, the cartilaginous skeleton and uncovered gill-slits, the embryo salmon, pike, perch, etc., as Owen observes, manifest transitory characters which are permanent in sharks (*Selachii*).

A summary of the changes undergone in the bony fishes is as follows:

1. Segmentation partial.
2. A gastrula-condition in the lamprey and sturgeon, but not in the bony fishes (trout, etc).
3. The embryo arises as in any other vertebrate.

[1] The Structure and Growth of Domesticated Animals," 20th Ann. Report of the Secretary of the Massachusetts Board of Agriculture. Boston, 1873. These were kindly loaned by Mr. C. L. Flint, the Secretary.

4. Adult form attained at the time of hatching or birth, in the viviparous species; certain forms undergoing slight metamorphosis.

LITERATURE.

Vogt. Embryologie des Salmones (in Agassiz, Hist. Nat. des Poissons d'l'eau douce de l'Europe Centrale.) Neuchatel, 1842.

Lereboullet. Recherches d'Embryologie Comparée sur le Developpement der Brochét, de la Perche, etc. (Annales des Sc. Nat. Paris, 1855)

Œllacher. Beiträge zur Entwicklung der Knochenfische, etc. (Siebold and Kölliker's Zeitschrift, 1873, '74.)

Kowalevsky, Owsjannikoff, und Wagner. Entwickelung der Störe (Sturgeon. Bulletin Imp. Acad. St. Petersburg, xiv, 1873.)

With the writings of Kupffer, Götte, Ray Lankester and Owsjannikoff.

Development of the Amphibia. Passing by the Dipnoa (Ceratodus, Protopterus and Lepidosiren) of whose development we as yet are totally ignorant, and the Simosauria, Plesiosauria and Ichthyosauria, we come to the salamanders and toads and frogs, or Amphibia. The early history of the extinct Archegosaurus, Dendrerpeton and Labyrinthodonts died with them, and we can only predicate from the imperfectly known structure of the adult forms that their young possibly developed in a manner like that of the living batrachians.

As in the fishes the batrachians are most highly colored during the breeding season. The males of certain newts acquire the dorsal crest and a broader tail-fin, aiding in the process of fecundation (Owen), and other secondary sexual features are added, especially to the male during the reproductive season. After an imperfect sexual union the salamanders deposit their eggs on the leaves of aquatic plants. The eggs of the toad are laid in long strings, those of the frog in masses. In these creatures each egg is fertilized as it is extruded, and the egg then swells greatly, the yolk appearing as a dot in the large jelly-like mass surrounding it.

Until we have a detailed embryology of the Amphibians, studied in the light of the newer school of embryology, the reader must be content with the following summary of Owen's account in his "Anatomy of Vertebrates."

The segmentation of the egg in the Amphibia is total, the process beginning usually about three hours after impregnation in the frog, and lasting twenty-four hours. The primitive streak, the notochord and nervous system then arise as in other craniated Vertebrates. After the appearance of the branchial arches, the gills begin to bud out from them, finally forming the larger gills

of the tadpole. The embryo now rests on the large yolk sac, much as in the embryo fish, but this is entirely absorbed before the embryo leaves the egg. Before the yolk-sac is absorbed a communication opens between the alimentary canal and the branchial cavity in the head (bucco-branchial cavity of Owen), "and this opens externally on the lower part of the head by a vertical fissure, on each side of which a small protuberance buds out, forming a special organ of adhesion — a pair of temporary cephalic limbs." (Owen.) Now the gills having got their growth, the remnant of the yolk enclosed by the abdominal walls, and the tail well developed, the tadpole bursts its egg membrane and swims about freely. In Italy, Rusconi found that the tadpoles hatched in four days, in England they hatch in five days, and the period may be prolonged to four weeks by cold weather. It is a common sight in Maine to see frogs' eggs laid in ponds still containing ice and snow.

The tadpole is much less developed than the larval fish or any other vertebrate; the intestine is not yet formed, and in other important characters it is lower in organization than the freshly hatched fish. It is also a vegetarian, eating decaying leaves; the mouth is small and round, the alimentary canal is remarkably long, the intestine coiled up in a spiral, the mouth is small, destitute of a tongue and the beak unarmed with teeth. "About the middle period of aquatic life the true or permanent kidneys begin to be formed from and upon the primordial ones; and the basis of the ovaria, or testes, may now be discerned. The oviduct is soon distinct from the ureter; but the testes retain the same excretory duct as the kidneys; their *vasa deferentia* communicate with retained cæca of the primordial kidneys before penetrating the later glands; the upper or anterior ends of the first remain for some time behind the heart." (Owen.)

"Soon after the external gills have reached their full development they begin to shrink, and finally disappear; but the branchial circulation is maintained some time longer upon the internal gills; these consist of numerous short tuft-like processes from the membrane covering the cartilaginous branchial arches; they are protected by the growth of a membranous gill-cover, which, as the external branchiæ are absorbed, leaves only one small external orifice, by which the branchial streams, admitted by the mouth, continue to be expelled. The chief distinction between the fully

developed branchial circulation in the Batrachian larva and that of the fish consists in the presence of small anastomosing channels, between the branchial artery and vein of each gill, proximad of the gill itself. The tongue makes its appearance when the fore limbs are developed."

The vertebræ of the tadpole are biconcave, but in the change to the adult are converted into cup-and-ball joints, by ossification of the substance of the cavities, and its coalescence either with the fore (Pipa) or back (Rana) part of the centrum. The remarkable changes in the hyo-branchial apparatus and the skull are described by Owen.

The accompanying figures (from Tenney's Zoology) represent the external changes of the toad from the time it is hatched until the form of the adult is attained. The tadpoles of our American toad, as observed in the European toad by Owen, are smaller and blacker in all stages of growth than those of the frog. The tadpole is at first without any limbs (Fig. 297); soon the hinder pair bud out. After this stage (Fig. 298) is reached, the body begins to diminish in size. The next important change is the growth of the front

Fig. 299.

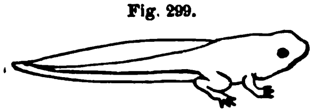


Fig. 298.

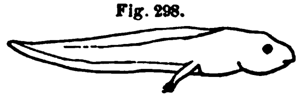


Fig. 297.

Fig. 300.

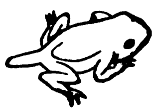


Fig. 301.

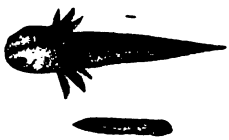
Metamorphosis of the Toad.

legs and the partial disappearance of the tail (Fig. 299), while very small toads (Figs. 300 and 301), during midsummer, may be found on the edges of the pools in which some of the nearly tailless tadpoles may be seen swimming about. When the tadpoles are hatched late, the gills are often retained through the winter, as large tadpoles of frogs are often found in pools by breaking through the ice. It is three years, according to Owen, before the Amphibia are capable of breeding.

"In the newts (Triton) the gills are in three pairs, larger and more complex than in the frog; the fore limbs are the first to

emerge, and the gills persist long after the hind limbs are developed." (Owen). While as a rule the eggs of newts or salamanders are laid in the water, the red-backed salamander lays its eggs in damp places on land, though the young are provided with gills. Fig. 302 (after Hoy) represents the young of *Amblystoma lurida* on the tenth day after hatching, the lower figure the natural size of the freshly hatched young. In the Surinam toad and Hyla of the island of Mauritius there is no metamorphosis, the young hatching with the form of the adult.

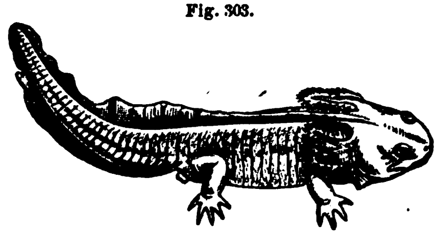
Fig. 302.



Larval Salamander.

The Siredon or Axolotl of Mexico, according to Dumeril, lays eggs, though a larva, while, as in the Axolotl, the larva of *Amblystoma mavortium*, originally described as an adult animal under the name of *Siredon lichenoides* (Fig. 303, from Tenney's Zoology) has been found by Professor Marsh to drop its gills and assume its adult form when brought to the sea level, its original habitat being the lakes situated in the Rocky Mountains at an altitude of 4,500 – 7,000 feet.

Fig. 303.



Siredon or larval Salamander.

Professor Owen has well summed up the wonderful changes undergone in these metamorphoses, which are exactly paralleled by those of the vegetarian larval gnat with biting jaws and gills into the blood-sucking volant, air-breathing fly; entirely new organs replacing the deciduous ones of the larva, and the body in attaining maturity being made over anew. "In the metamórphoses of the Batrachia," says the distinguished comparative anatomist, "we seem to have such process carried on before our eyes to its extremest extent. Not merely is one specific form changed to another of the same genus; not merely is one generic modification of an order substituted for another, the transmutation is not even limited by passing from one order (Urodela) to another (Anoura); it affects a transition from class to class. The Fish becomes the Frog; the aquatic animal changes to the terrestrial one; the water-breather becomes the air-breather; an insect diet is substituted for a vegetable one. And these changes, more-

over, proceed gradually, continuously, and without any interruption of active life. The larva having started into independent existence as a fish, does not relapse into the passive torpor of the ovum to leave the organizing energies to complete their work untroubled by the play of the parts they are to transmute, but step by step each organ is modified, and the behavior of the animal and its life-sphere are the consequence, not the cause, of the changes."

"The external gills are not dried and shrivelled by exposure to the air, nor does the larva gain its lungs by efforts to change its element and inhale a new respiratory medium. The beak is shed, the jaws and tongue are developed, and the gut shortened, before the young Frog is in a condition to catch a single fly. The embryo acquires the breathing and locomotive organs—gills and compressed tail—while imprisoned in the ovum; and the tadpole obtains its lungs and land-limbs while a denizen of the pool; action and reaction between the germ and the gelatinous atmosphere of the yolk, or between the larva and its aqueous atmosphere, have no part in these transmutations. The Batrachian is compelled to a new sphere of life by antecedent obliterations, absorptions and developments, in which external influences and internal efforts have no share."

While the passage we have quoted is an attack against Lamarckianism, we do not see but that in a long course of generations of the ancestors of the present species of amphibians, the metamorphoses may have become gradually established, finally becoming the normal history of each individual; the changes of the individual epitomizing the successive steps in the collective life-history of the entire group of Amphibians. That changes in the physical surroundings induce important modification of structure is seen in the exceptional mode of metamorphosis of the Surinam Pipa, or the Hyla of Mauritius, and on the other hand, in the prematurity of the axolotl, which near the level of the sea drops its gills, while five or six thousand feet above the sea it retains its gills and still produces young.

To recapitulate, we have the following stages of development in the Amphibia:

1. Morula (segmentation total).
2. The embryo develops as in the bony fishes.
3. Young with external gills hatching with a fish-like form, but

much less advanced in internal organization; or, rarely, hatching in the adult form, the metamorphosis being suppressed.

4. Larval forms retained as in the Menobranchus, Siren, Menopona and Salamanders; or dropped, as in the toad and frog.

LITERATURE.

Swammerdam. Biblia Naturæ. 1737.

Reichert. Vergleich. Entwickelungsgeschichte der nackten Amphibien. 1838.

Rusconi et Configliachi. Histoire Nat. Développement et Metamorphose de la Salamandre terrestre. Pavia, 1854.

Schultze. Observationes nonnullæ de Ovorum Ranarum Segmentatione, 1863. With papers by Prévost and Dumas, Newport, Horne, Dumeril and Marsh.

Development of the Reptiles. We now come to study the embryology of those vertebrates in which there is an important embryonal membrane, the *amnion*, developed, besides an *allantois*. The eggs of reptiles from their abundant supply of yolk cells, and the early stages of the embryo, are so much like those of birds that the reader is referred to the account of the early stages of the chick for a more complete account of the early phases of embryonic life in the reptiles.

As with birds, the eggs are enormous in size, and like those of the ostrich they are laid in the sand, and are left by the parent to be hatched by the warmth of the sun.

Professor H. J. Clark, in his "Mind in Nature," tells us that of all eggs those of turtles are by far the most easily preserved in a healthy state during the time of incubation. "All that is required to obtain them is to collect a number of turtles in early spring, before May, and keep them enclosed in some shady spot where they can have easy access to water and soft earth, and to feed them well with fresh herbage, such as plantain-leaves, lettuce, beet-leaves, etc., etc., and in the course of time, usually in May and June, they may be caught, at early dawn, digging holes in the earth with their hind legs, and depositing therein their brood of eggs, and then covering them up."

The lizards, snakes, and crocodiles, lay their eggs in sand or light soil, the iguana in the hollows of trees, while certain lizards and snakes are viviparous. Agassiz has discovered the extraordinary fact that in turtles fecundation does not appear to be an instantaneous act, resulting from one successful connection of the sexes, as it is with most animals, but "a repetition of the act, thrice every year, for four successive years, is necessary to determine

the final development of a new individual, which may be accomplished in other animals by a single copulation." From the same source we learn that *Chrysemys* (Emys) *picta* does not lay its eggs before the eleventh year. Our other turtles probably lay their eggs from the eleventh to the fourteenth year, according to the species. The operation takes place in the month of June, both at the north and south, climatic differences not seeming to have any effect upon this particular function.

Before segmentation of the yolk the nucleus, or germinal vesicle, undergoes self-division. According to Agassiz and Clark "this takes place, at least to a certain extent, without the influence of fecundation within a year, but at the same time has been seen only in those eggs which have been expelled from the ovary. Finally they become the original cells, "the primitive embryonic cells" engaged in the composition of the different organs of the body. In the bony fishes, according to Œllacher, the germinal vesicle is ejected bodily from the germinal disk, and Foster and Balfour think this fate awaits that of the birds. In insects the germinal vesicle is supposed to undergo self-division and form the nuclei of the cells of the blastoderm.

The segmentation of the yolk has been fully observed in *Glyptemys* (Emys) *insculpta*. The process of segmentation is not so regular, and there does not seem to be always, in the beginning, a symmetrical halving of the embryonic area, as has been observed among birds; but in other respects it resembles what takes place within the eggs of the latter animals, and finally results in shaping out the embryonic disk." Agassiz and Clark, from whom we have quoted, think, however, that, from certain phenomena observed by them, the whole mass of the yolk becomes segmented.

The formation of the primitive streak, the amnion, allantois, and *chorda dorsalis*, are much as observed in the chick, and for an account of the early stages of the embryo reptiles, the reader is referred to the chapter on the embryology of birds. The lungs arise as hollow sacs projecting from the sides of the throat; the liver is a thickening of the same membrane from which the stomach is formed, while the reproductive glands "arise in intimate connection with the posterior end of the intestine."

By the time that the heart has become three-chambered, the vertebræ have reached the root of the tail, the eyes have become entirely enclosed in complete orbits, and the allantois begins

to grow. Soon after, the embryo turns upon its axis, and always rests on its left side. The nostrils may now be recognized as two simple indentations at the end of the head, and at first are not in communication with the mouth, but soon a shallow furrow leads to it.

The shield begins to develop by a budding out laterally of the musculo-cutaneous layer along the sides of the body, and the growth of narrow ribs extending to the edge of the shield. "The feet, or rather paddles, of the lower forms of turtles, the Chelonioidæ, do not remain in a partially undeveloped state, as might be expected from what is observed among other vertebrates, but undergo what may be called an excess of development; the bones of the toes becoming very much elongated, and the web—which remains soft among some turtles with moderately elongated toes, —is hardened by the development of densely packed scales, so that the whole foot is almost as rigid as the blade of an oar. At this time the embryo of *Chelydra serpentina* snaps at everything which touches it.

Of the development of the Saurians, or lizards, we have no complete account. The advanced embryo of the lizard, as figured by Owen (443), is like that of the turtle without its shell.

As regards the development of snakes, Owen, deriving his information from Rathke's work, tells us that in the oviparous snakes (*Natrix torquata*) the embryo partially develops before the egg is laid, while the young hatches in two months after the egg is deposited. By this time the amnion is perfected, "the head is distinct, and shows the eye-ball and ear-sac; also the maxillary and mandibular processes. The allantois is about as large as the head." The long trunk of the serpent grows in a series of decreasing spirals, and when five or six are formed, the rudiment of the liver and the primordial kidneys are discernible." At the latter third of embryonic life the right lung appears as a mere appendage to the beginning of the left.

A summary of the changes in the egg undergone by the reptiles is as follows:

1. Segmentation partial, possibly total (morula?).
2. The embryo develops much as in the bony fishes until the embryonal membranes appear.
3. Formation of an amnion.
4. After the alimentary canal is sketched out, the allantois buds out from it.

5. The shield of the turtle develops and the reptilian features are assumed.

6. The embryo hatches in the form of the adult, there being no metamorphosis.

LITERATURE.

Rathke. Entwickelungsgeschichte der Natter. Königsberg, 1837.

——. Entwickelung der Schildkröten. Braunsschwieg, 1848.

——. Ueber die Entwickelung und den Körperbau der Krokodile. Braunsschwieg. 1866.

Agassiz and Clark. Embryology of the Turtles in Agassiz's Contributions to the Natural History of the United States, II, part iii, 1857.

Development of Birds. So much alike are all the living species of birds that the embryology of a single kind is in all probability a type of that of the others. The development of the domestic fowl has been studied in more detail than any other vertebrate, since it is easy to hatch the eggs artificially, and from their large size they can be examined more readily than the eggs of fishes. Our account of the embryology of birds will be taken from the admirable account by Foster and Balfour in their "Elements of Embryology," and we shall freely use their work, often quoting them, word for word, where it is not possible to farther condense their language.

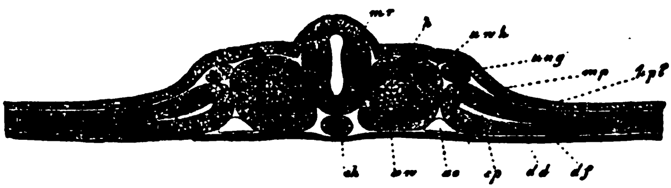
The eggs of the hen are fertilized in the upper extremity of the oviduct, whether before or after the "white" of the egg is deposited is unknown, but at any rate before the shell is deposited around the "white."

First day. As the first result of impregnation the germinal vesicle disappears, probably being, judging from the analogy of the bony fishes, bodily ejected from the germinal disk. Then begins the process of segmentation of the yolk, which goes on at about the time the shell is formed. Segmentation is partial, being restricted to the germinal disk of the ovarian egg; the result is the formation of the blastodermic disk, which is the beginning of the embryo, resting on the upper surface of the yolk and appearing as a pale round spot seen in the freshly laid egg. This blastoderm at first consists of two layers of cells, the upper made up of nucleated cells, and the lower of irregular rounded masses called "formative cells."

Now begins the marking out of the embryo, which develops in the "*area pellucida*" a transparent rim (encompassed by the "*area opaca*") surrounding the blastoderm. The first step is the origin of an inner germ-layer, the two others having previously

arisen, so that we now have the three germ-layers found in all vertebrates and in some invertebrates. From the outer layer (epiblast) arises the tegument and walls of the body, with the nervous cord; while from the second (mesoblast) are formed the heart and the vascular system or blood-vessels, and the stomach and intestines. The third and innermost layer is called the "hypoblast." By the sixth or eighth hour these three membranes become definitely established. The middle layer now thickens and thus causes the appearance known as the "primitive streak," along the middle of which runs the depression known as the "primitive groove." In front of the primitive groove appears the "medullary groove," and below it the notochord or "*chorda dorsalis*" originates from the cells of the middle layer. This notochord (Fig. 304, *ch*) lies directly beneath the medullary tube

Fig. 304.



Section of an Embryo Hen.

(*mr*) and between the outer and third germ-layer in the form of a flattened circular rod. The blastoderm is now folded anteriorly like the letter S; this is called the "head-fold," and soon after the "tail-fold" is formed in a similar way. These two folds meet in the middle thus forming the body of the embryo.

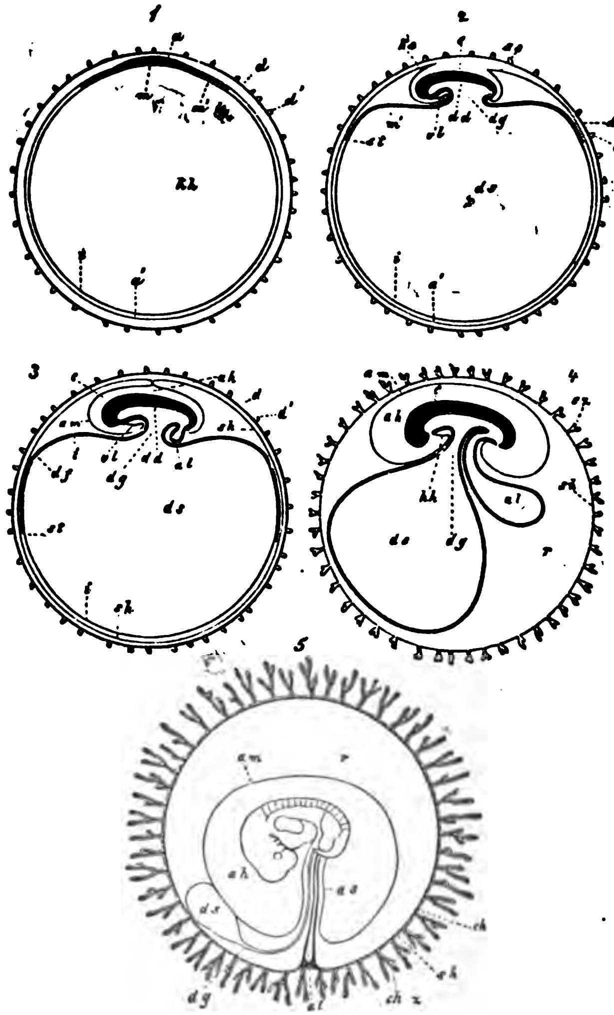
Next the primitive groove and streak disappear as the sides of the medullary groove rise up, when they finally meet, forming the neural tube, or hollow in which the nervous cord is formed.

About this period the first pair of protovertebræ make their appearance. They arise from the mesoblast as two cubical masses (Fig. 304[1], *u w*) lying one on each side of the notochord. Two more pairs appear behind the first pair before the first day is

[1] Fig. 304; *dd*, third or inner germ-layer (darmdrüsenblatt or hypoblast); *ch*, *chorda dorsalis* or notochord; *uw*, primitive vertebræ, or protovertebræ; *uwh*, cavity in the protovertebræ; *ao*, primitive aorta; *ung*, Wolffian duct; *sp*, split in the middle-germ layer, the beginning of the pleuro-peritoneal cavity (mesoblast) by which it is divided into two layers, the lower layer (*df*) the splanchnopleure (or darmfaserplatt), the upper layer (*hpl*) being the somatopleure (hautplatt), the two layers unite at *mp* (Kölliker's mittelplatt); *mr*, medullary tube (rückenmark); *h*, outer germ-layer (hornblatt or epiblast).

ended. "Out of the protovertebræ are formed not only the permanent vertebræ, but also the superficial dorsal as well as certain

Fig. 305.



Early stage of a Vertebrate (Fowl).

other muscles and the spinal nerves. The pair of protovertebræ first formed corresponds not with the first cervical vertebra of the adult chick, but rather with the third or even fourth; for though

the majority of the protovertebræ are formed regularly behind the first pair, two or even three pair may make their appearance in front of it" (Foster and Balfour).

Fig. 304 (from Kölliker) is a cross section through an embryo chick of the second day magnified 90–100 times, showing the relations of the medullary tube, *chorda dorsalis* and protovertebræ.

Meanwhile the middle layer has split into two layers; the upper (or outer) leaf is called the "somatopleure," so-called from its giving rise to the body walls, while the lower (or inner) leaf is called the "splanchnopleure," as it is destined to form the alimentary canal, and the liver and other glands originating from the digestive cavity.

The amnion next arises from certain folds of the somatopleure. As the embryo thickens and sinks into the yolk two folds grow out of the head and tail end respectively (Fig. 305, 2, *ks* and *ss*). These finally meet and coalesce on the fourth day over the back of the embryo, forming the amniotic cavity (Fig. 305, 3, *ah*) in which the embryo lies. The fluid which fills this cavity is called the amniotic fluid.

The allantois arises as an appendage of the alimentary canal, budding out at the hinder end of the embryo. It finally grows (as in Fig. 305, 4, *al*) so large as to curve over the embryo, serving as a fœtal respiratory organ.[1]

Second Day. By the time the embryo is thirty hours old the outlines are bolder, more distinct and the tissues firmer, so that

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[1] Fig. 305. Five schematic figures showing the development of the fœtal egg-membranes, where in all except the last the embryo is represented as if seen in longitudinal section. 1. Egg with *zona pellucida* (embryonic sac) blastoderm (*a*, *l*) germinal disk and embryo. 2. Egg with the first traces of the yolk sac (*d*) and amnion (*ks*, *ss* and *am*). 3. Egg with the amnion uniting and forming a sac; the allantois (*al*) budding out. 4. Egg with the villi of the serous membrane (*sz*); the allantois larger; embryo with mouth and anal opening. 5. Egg in which the vascular layer of the allantois lies close to the serous layer and has grown into the villi of the same, constituting the true chorion (*ch*). Yolk sac much smaller, about to be drawn into the cavity of the amnion.

d, yolk-skin; *d'*, villi of the yolk-skin; *sh*, serous membrane: *sz*, villi of the serous membrane: *ch*, chorion (vascular layer of the allantois) *chz*, true villi of the chorion (arising from the projections of the chorion and the sac of the serous membrane); *am* amnion; *ks*, head-fold of the amnion; *ss*, tail-fold of the amnion; *ah*, cavity of the amnion; *as*, sheath of the amnion for the navel string; *a*. the first beginning of the embryo arising from a thickening of the outer layer of the blastoderm *a'*; *m*, thickening forming the germ in the middle layer of the blastoderm (*m'*), which at first only reached as far as the germinal disk, and afterwards forms the vascular layer of the yolk-sac (*df*) which connects with the intestino-muscular layer (darmfaserplatte); *st*, *sinus terminalis*; *dd*. intestino-glandular layer (darmdrusenblatt) arising out of a part of *i*, the inner layer of the blastoderm (afterwards the epithelium of the yolk-sac; *kh*, cavity of

the whole blastoderm can be removed from the egg with much greater ease than before. The head-fold has now become more prominent than before. The nerve-tube, at first of uniform thickness dilates anteriorly forming the first cerebral vesicle, and the second and third cerebral vesicles successively form, the protovertebræ increase rapidly, and soon the embryonic chick presents the appearance of the embryo rabbit of nearly the same age.

The alimentary canal commences as a *cul de sac*, closed in front but widely open behind, situated below the anterior end of the medullary tube. The heart originates also in the head-fold at about the time the protovertebræ are formed, and the rudiment is situated below the fore gut or rudiment of the alimentary canal; by the end of the first half of the second day it is flask-shaped, with a slight bend to the right. "Soon after its formation the heart begins to beat, its at first slow and rare pulsations beginning at the venous and passing on to the arterial end." Its movements begin before the cells of which it is composed are differentiated into muscle or nerve-cells. To provide channels for the fluid pressed out by the contractions of the heart, the heart divides into the two primitive aortæ, and connects with other embryonic temporary arteries and veins. Meanwhile in the vascular area and *area pellucida*, the arteries, capillaries and veins rapidly develop, and blood disks arise as amœba-like cells separating from the adjacent cell-mass of the mesoblast (middle germ-layer), while the vessels are contemporaneously forming; the red blood corpuscles not being true cells, but nuclei. The first half of the second day ends with the rise of the rudiment of the Wolffian duct. "It is important to remember that the embryo of which we are now speaking is simply a part of the whole germinal membrane, which is gradually spreading over the surface of the yolk. It is important also to bear in mind that all that part of the embryo which is in front of the most anterior protovertebræ corresponds to the future head, and the rest to the neck, body and tail. At this

the blastoderm, which afterwards becomes *ds*, the cavi y of the yolk-sac; passage way of the yolk; *al*, allantois; *e*, embryo; *r*, original space between the amnion and chorion, filled with albuminous fluid; *vl*, anterior body-wall in the region of the heart; *hh*, cavity of the heart without the heart itself.

In Figs. 2 and 3, the amnion is for the sake of clearness represented as situated too far away from the embryo; so also the cavity of the heart is drawn too small and the embryo too large, since except in Fig. 5, they are only drawn diagrammatically. These and Fig. 304, from Kölliker's Entwickelungsgeschichte des Menschen und der hoheren Thiere.

period the head occupies nearly a third of the whole length of the embryo" (Foster and Balfour).

In the second half of the second day, among the most important changes are the appearance of the second and third cerebral vesicles, the optic vesicles, while the "first rudiment of the ear is formed as an involution of the epiblast on the side of the hind brain or third cerebral vesicle."

Third day. This day is one of the most eventful, as the rudiments of so many important organs now first appear. First, the embryo, now almost completely enveloped by the amnion, turns around so as to lie on its left side. The heart, originally formed under where the brain is destined to lie, moves backward into the trunk, and by this time (the third day) the neck has been formed, in which appears the four branchial fissures, the most anterior being formed first. It is these temporary fissures which correspond to the branchial fissures of Amphioxus. "On account of this resemblance—in fact by some assumed as an identity both in form and function—the fissures have been called by embryologists the *branchial fissures* (compare Fig. 288) and the vessels [passing between them] the branchial aortæ, the former corresponding with the passages between the gills of fishes, and the latter with the vessels which supply the gills with blood" (Clark's Mind in Nature, p. 311).

In fact the embryo bird in some respects is now as far advanced in organization as the Lancelet, and may be rudely compared with that animal, though the incipient neck, head and brain are features which the Lancelet lacks.

The eye commences as a lateral outgrowth of the fore brain, in the form of a stalked vesicle subsequently converted into the optic nerve, while the lens is formed by an involution of the skin of the body (outer germ-layer) over the front end of the optic vesicle. The ear is also at first simply an involution of the outer germ-layer (epiblast) forming a pit, or "otic vesicle," which is destined to form the internal ear, containing the bones and other parts of the inner ear. The nose begins as two shallow pits formed by the sinking in of the outer germ-layer. Each of these pits is situated next to the olfactory vesicles (afterwards nerves), but at first there is no connection between the pits and the nerves as between the pits and the mouth, which is in fact not yet formed, since it arises afterwards as an extension inward of the cleft be-

tween the first branchial folds and its branch, as the jaws or maxillæ arise from the first fold, the upper jaws being two branches of the fold, the fold itself being the under jaw, while a lozenge-shaped cavity between the fold and its branches becomes the mouth.

Meanwhile, for all the changes in the different organs are going on contemporaneously, the vesicles or lateral expansions of the nerve-tube appear, the vesicles of the cerebral hemispheres developing, as well as the separation of the hind-brain into the cerebrellum and *medulla oblongata*. The digestive cavity is during the third day also, differentiated into the fore-gut and hind-gut, the former farther subdividing into the œsophagus, stomach and duodenum, and the hind-gut into the large intestine and cloaca. The lungs arise as two pocket-like appendages of the alimentary canal immediately in front of the stomach; while the liver is originally two diverticula, and the pancreas a single offshoot from the duodenum.

Fourth day. With a decided increase in size by this day, the amnion becomes more distinct, and the allantois is visible. The wings and legs now appear as flattened conical buds arising from the "Wolffian ridge," a low ridge running from the neck to the tail, those forming the wings being scarcely distinguishable from the rudimentary legs.

The olfactory grooves appear at this time and the partition heretofore existing between the mouth and throat is absorbed and disappears.

The protovertebræ have, by this time, increased in number from thirty to forty. The upper portion (muscle-plate) having previously separated to form the muscles inserted in the skeleton (episketal muscles of Huxley), has left the remainder of each protovertebra as a somewhat triangular mass, the upper angle of which grows up and meets its fellow in the median line above, thus enclosing the nerve-canal. On the lower side each protovertebra sends out a similar growth enclosing the notochord. "While the inner portion of each protovertebra is thus extending inwards around both notochord and neural canal, the remaining outer portion is undergoing a remarkable change. It becomes divided into an anterior or præaxial, and a posterior or postaxial segment. The anterior, which is the larger and more transparent of the two, is the rudiment of the spinal ganglion and nerve, while the pos-

terior, which remains more particularly connected with the extensions round the neural canal and notochord, goes to form part of the permanent vertebra. In this way each protovertebra, having given rise to a muscle-plate, is farther subdivided into a ganglionic rudiment, and into a mass which we may speak of as a 'primary' vertebra, consisting as it does of a body or mass investing the notochord, from which springs an arch covering in the neural canal." (Foster and Balfour.) The conversion of the primary vertebræ or membranous vertebral column into the permanent vertebræ is "complicated by a remarkable new or secondary segmentation of the whole vertebral column," so that "each permanent vertebra is formed out of portions of two consecutive protovertebræ. Thus, for instance, the tenth permanent vertebra is formed out of the hind portion of the tenth protovertebra, and the front portion of the eleventh protovertebra, while its arch, now attached to its front part, was attached to the hind part of the tenth protovertebra." (Foster and Balfour).

By the sixth day the notochord begins to diminish and disappear by the time the bird is hatched, while by the twelfth day the ossification of the bodies of the vertebræ commences, the process beginning in the second or third cervical, and thence extending backwards. The ribs begin as a downward growth from the exterior of the vertebra, at first separate from the bodies of the vertebra.

Between the eightieth and one hundredth hour of incubation the permanent kidneys arise, and previous to this the sexual glands have arisen out of the middle germ-layer, from the germinal epithelium lying at the upper end of the pleuroperitoneal cavity. In this epithelium may be seen certain large cells, the primordial ova, which are at first seen in male as well as female embryos, so that in early stages it is impossible to distinguish the sexes. Between the eightieth and one hundredth hour, however, the primordial ova disappear in those embryos destined to be males, while they enlarge and multiply in the female. "The large nucleus of the primordial ovum becomes the germinal vesicle, while the ovum itself remains as the true "ovum." The testes begin to arise on the sixth day.

Fifth day. This period is signalized by the further growth of the allantois, and by the appearance of the knee and elbow, and of the cartilages which precede the formation of the bones of the

digits and limbs; as well as the formation of the primitive skull, with the development of the parts of the face, and the formation of the anus.

The cranium, from the researches of Rathke, Parker and others, is formed from the middle germ-layer, and in the fourth day is simply membranous; after that time the tissue composing it becomes cartilage. After the fourth day the primitive skull consists of two portions, *i.e.*, a sheet of cartilage ensheathing the notochord from its anterior end to the first vertebra. "This sheet of cartilage forms an *unsegmented* continuation of the vertebral bodies. It is to be considered as the most anterior portion of the axial skeleton, in which the segmentation has become obliterated; and as such is equivalent not to one, but to a (hitherto not certainly determined) number of vertebræ." (Foster and Balfour. For the farther changes in the development of the skull the reader is referred to Parker's memoir on the Development of the Skull of the Common Fowl, or the excellent, illustrated abstract in Foster and Balfour's "Elements.")

Not until the sixth day are distinct bird-characters developed. Hitherto it would be almost impossible to distinguish the embryo from a reptile or mammal. During the sixth and seventh day the wing and foot assume a bird form, the crop and intestinal cœca make their appearance, "the stomach takes the form of a gizzard, and the nose begins to develop into a beak, while the incipient bones of the skull arrange themselves after the avian type. . . . From the eleventh day onwards the embryo successively puts on characters which are not only avian, but even distinctive of the genus, species and variety." By the ninth or tenth day the feathers originate in sacs in the skin, these sacs by the eleventh day appearing to the naked eye as feathers, the sacs however remaining closed as late as the nineteenth day, though many are an inch in length.

The nails and scales begin to appear on the thirteenth day. "By the thirteenth day the cartilaginous skeleton is completed, and the various muscles of the body can be made out with tolerable clearness. Ossification begins, according to Von Baer, on the eighth or ninth day by small deposits in the tibia, in the metacarpal bones of the hind-limb, and in the scapula. On the eleventh or twelfth day a multitude of points of ossification make their appearance in the limbs, in the scapular and pelvic arches, in the

ribs, in the bodies of the cervical and dorsal vertebræ, and in the bones of the head, the centres of ossification of the vertebral arches not being found till the thirteenth day."

While the blood is at first aerated by the allantois, and there is a partial double circulation of the blood, as soon as respiration begins a completely double circulation is formed.

After the sixth day muscular movements of the embryo probably begin, but they are slight until the fourteenth day, when the embryo chick changes its position, lying lengthways in the egg, with its beak touching the chorion and shell membrane, where they form the inner wall of the rapidly increasing air chamber at the broad end. On the twentieth day or thereabouts, the beak is thrust through these membranes, and the bird begins to breathe the air contained in the chamber. Thereupon the pulmonary circulation becomes functionally active, and at the same time blood ceases to flow through the umbilical arteries. The allantois shrivels up, the umbilicus becomes completely closed, and the chick piercing the shell at the broad end of the egg with repeated blows of its beak, casts off the dried remains of allantois, amnion and chorion, and steps out into the world." (Foster and Balfour).

A brief summary of the changes undergone by the developing chick will be seen to be nearly identical with that of reptiles:

1. Partial segmentation of the yolk.
2. The embryo develops much as in the bony fishes until the embryonal membranes appear.
3. Formation of an amnion.
4. After the alimentary canal is sketched out, the allantois buds out from it.
5. The avian features appear from the sixth to the tenth day.
6. The embryo leaves the egg in the form of the adult, and like the reptile, is at once active, feeding itself.

LITERATURE.

Harvey. Exercitationes anatomicæ de Generatione Animalium. London, 1651.

Malpighi. De Formatione Pulli in Ovo. London, 1672.

Haller. Sur la Formation du Cœur dans le Poulet. London, 1758.

——. Elementa Physiologiæ, Liber xxix. 1766.

Wolff. Theoria Generationis. Halle, 1759.

Pander. Dissertatio inauguralis sistens Historiam Metamorphoseos quam Ovum incubatum prioribus quinque diebus subit. Würzburg, 1817.

——. Beiträge zur Entwickelungsgeschichte des Hühnchens im Eie. Würzburg 1817.

Purkinje. Symbolæ ad Ovi Avium Historiam. Vratislav, 1825.

Von Baer. Ueber Entwicklungsgeschichte der Thiere. Königsberg. 1828.
Reichert. Das Entwicklung leben im Wirbelthierreich. Berlin, 1840.
Erdl. Die Entwicklung des Menschen und des Hühnchens im Ei. Theil 1. Leipzig, 1845.
Remak. Untersuchungen über die Entw'ckl ng der Wirbelthiere. Berlin, 1855.
Parker. On the Development of the Skull of the Common Fowl (Phil. Trans. CLVI, 1. London, 1866.)
Foster and Balfour. The Elements of Embryology, Vol. I. London, 1874.
With the works of Coste, Allen Thompson and others.

PLANTS THAT EAT ANIMALS.[1]

BY MRS. MARY TREAT.

THE Bladderwort is a common plant, growing in shallow ponds and swamps; Dr. Gray in his "Manual of the Botany of the United States," describes twelve species found within this range, and almost every muddy pond contains one or more of them. Some grow wholly or nearly out of water; but the species which I am about to describe are immersed, with finely dissected leaves on long stems floating in the water. Scattered among the leaves, or along the stems which are destitute of leaves, are numerous little bladders, the use of which we had supposed was to float the plant at the time of flowering. The flowering stems of most of the species are smooth and free from leaves or bladders, and shoot up straight from the water to a hight of from three to twelve inches, bearing at the top from one to ten curiously-fashioned flowers of a yellow or purple color. It has always been taken for granted that these little bladders were made to float the plant, although I had noticed that the stems most heavily laden with bladders sank the lowest in the water.

Fig. 306.

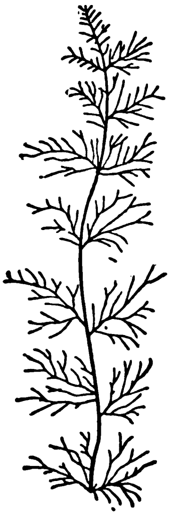
A portion of the stem, showing bladders. Natural size.

About a year ago (in Dec. 1873), a young man, now at Cornell University, and myself, on placing some of the bladders under the microscope, noticed animalcules—dead entomostraca, etc., apparently imprisoned therein. But our attention was not sufficiently

[1] This reprint with some alterations from the "New York Tribune," has been delayed until the publication of Mr. Darwin's last book gives fresh cause for its appearance. We are indebted to the "Tribune" for the use of the illustrations.

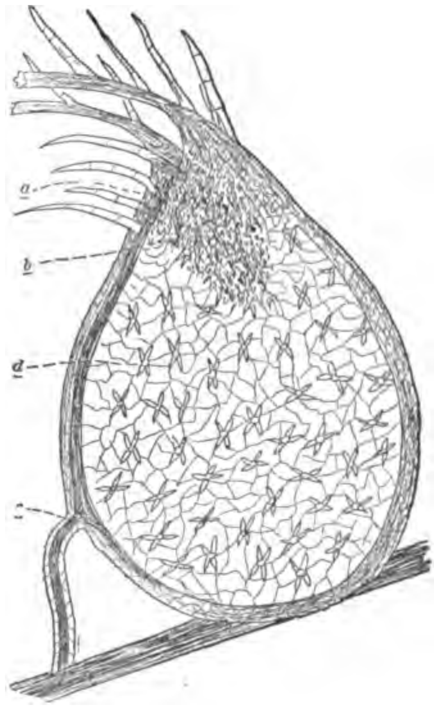
aroused to follow up the subject very closely; we laughingly called it "our new carnivorous plant." But as the bladders always seemed to be open, the significance of the fact of the imprisoned animal was not very apparent. We thought it could hardly be for the purpose of feeding the plant, but a kind of wanton cruelty. Still, my curiosity was aroused. I soon found larger animals in the bladders — dead larvæ of some aquatic insect — large enough

Fig. 307.



A portion of the stem and leaves, destitute of bladders.

Fig. 308.



The Bladder of Bladderwort. *a*, entrance; *b*, tunnel-like trap; *c*. point of attachment; *d*, a stellate point. This figure is magnified with a low power.

to be seen distinctly with the naked eye. But I was not aroused to earnest work until I watched the movements of an imprisoned living larva, and saw its struggles and final death. This was in October, 1874. I now visited the ponds and procured abundant material.

The plant that I experimented with mostly was the one known to botanists as *Utricularia clandestina*.

My next work was to see what prevented the escape of the animal from the bladder, and to this end I directed all my attention for several days. The animal that I found most commonly entrapped was a Chironomus larva, about the length of the mosquito larva, but more slender and of lighter color. I have frequently trapped these snake-like larvæ and seen them enter the bladders. They seem to be wholly vegetable feeders, and specially to have a liking for the long hairs at the entrance of the bladders. When a larva is feeding near the entrance it is pretty certain to run its head into the net, whence there is no retreat. A large larva is sometimes three or four hours in being swallowed, the process bringing to mind what I have witnessed when a small snake makes a large frog its victim.

I worked with this larva for several days, determined, if possible, to see him walk into the trap.

I put growing stems of the plant in a small dish of water with several larvæ, and set it aside. In a few hours thereafter I would find the living larvæ imprisoned. This served for another purpose, but not for the object I was aiming at. Forced to give up this plan of seeing the larvæ enter the bladder, I now directed my attention to the smaller ones — animalcules proper, — I placed the bladders in water inhabited by numerous tiny creatures, and soon had the satisfaction of seeing the *modus operandi* by which the victim was caught.

The entrance into the bladder has the appearance of a tunnel-net, always open at the large end, but closed at the other extremity. I find that the net is simply a valve turned in from the mouth of the bladder, with the outer edge surrounded with a dense mass of hairs, which impels the larva forward and prevents the possibility of retreat. The little animals seemed to be attracted into this inviting retreat. They would sometimes dally about the open entrance for a short time, but would sooner or later venture in, and easily open or push apart the closed entrance at the other extremity. As soon as the animal was fairly in, the forced entrance closed, making it a secure prisoner.

Entomostraca too were often captured — *Daphnia*, *Cyclops* and *Cypris*. These little animals are just visible to the naked eye, but under the microscope are beautiful and interesting objects. The lively little Cypris is encased in a bivalve shell, which it opens at pleasure, and thrusts out its feet and two pairs of antennæ, with tufts of feathery-like filaments. This little animal was quite

wary, but nevertheless was often caught. Coming to the entrance of a bladder it would sometimes pause a moment and then dash away; at other times it would come close up, and even venture part way into the entrance and back out as if afraid. Another, more heedless, would open the door and walk in; but it was no sooner in than it manifested alarm, drew in its feet and antennæ and closed its shell. But after its death the shell unclosed again, displaying its feet and antennæ. I never saw even the smallest animalcule escape after it was once fairly inside the bladder.

So these points were settled to my satisfaction — that the animals were entrapped, and killed, and slowly macerated. But how was I to know that these animals were made subservient to the plant? If I could only prove that the contents of the bladders were carried directly into the circulation, my point was gained. This now was my sole work for several days, to examine closely the contents of the bladders. I found the fluid contents to vary considerably, from a dark, muddy, to a very light, transparent color. Hundreds of these bladders, one after another, were put to the test under the microscope, and I found that to a greater or less extent, I could trace the same color that I found in the bladder, in the stem on which the bladder grew, though the observation was not so clear and satisfactory as I could wish. After more critical examination I arrived at the conclusion that the cells themselves and not their contents, change to a red color; the stems also take on this color, so as to make it appear as if a red fluid was carried from the bladders into the main stem, which is not specifically the fact so far as the observations yet made determine; though the main point, that the contents of the bladders are carried into the circulation, does not seem open to question.

The next step was to see how many of the bladders contained animals, and I found almost every one that was well developed contained one or more, or their remains, in various stages of digestion. The larva of Chironomus was the largest and most constant animal found. On some of the stems that I examined, fully nine out of every ten of the bladders contained this larva or its remains. When first caught it was fierce, thrusting out its horns and feet and drawing them back, but otherwise it seemed partly paralyzed, moving its body but very little; even small larvæ of this species that had plenty of room to swim about were soon very quiet, although they showed signs of life from twenty-four to thirty-six hours after they were imprisoned. In about twelve hours, as

nearly as I could make out, they lost the power of drawing their feet back, and could only move the brush-like appendages. There was some variation with different bladders as to the time when maceration or digestion began to take place, but usually, on a growing spray in less than two days after a large larva was captured, the fluid contents of the bladders began to assume a cloudy or muddy appearance, and often became so dense that the outline of the animal was lost to view.

Nothing yet in the history of carnivorous plants comes so near to the animal as this. I was forced to the conclusion that these little bladders are in truth like so many stomachs, digesting and assimilating animal food. What it is that attracts this particular larva into the bladders is left for further investigation. But here is the fact that animals are found there, and in large numbers, and who can deny that the plant feeds directly upon them? The why and wherefore is no more inexplicable than many another fact in nature. And it only goes to show that the two great kingdoms of nature are more intimately blended than we had heretofore supposed, and, with Dr. Hooker, we may be compelled to say, "our brother organisms—plants."

About the 1st of December, after I had made most of my observations, I wrote to Dr. Asa Gray and to Mr. Darwin, both on the same day, telling them of my discovery. Dr. Gray then informed me that Mr. Darwin had been engaged in the same work on *Utricularia*, and also sent me a note from him, bearing date Aug. 5. From this note it would appear that at that date he had not worked the matter up as far as I had — at least had not found so many imprisoned animals; but with his superior facilities he may have far outstripped me.

REVIEWS AND BOOK NOTICES.

ALLEN'S STUDIES IN THE FACIAL REGION.[1]—Though these essays are for the most part jottings from lectures delivered to dental students, naturalists will take an interest in the last chapter on the "Nomenclature of the Teeth," while the first chapter on the "Region of Expression," is an interesting one.

[1] Studies in the Facial Region. By Harrison Allen, M.D. Illustrated with 56 woodcuts. J. B. Lippincott & Co. Philadelphia, 1875. 8vo, pp. 117.

ZOOLOGY.

CAVE-INHABITING SPIDERS.—Naturalists are paying much attention to cave animals, and the modification of their organs due to their life either in twilight or total darkness. In some the eyes are entirely wanting, while the appendages are variously modified to remedy, as it were, the loss of eyesight. M. Simon of Paris has lately published in the "Annales of the Entomological Society of France," an interesting memoir on certain new spiders and allied forms inhabiting either caves or subterranean abodes in the soil of southern Europe. Some of these arachnids live simply in porous soil, but at great depths, and probably in small galleries. Such species he calls *hypogeal* (*hypogés*) and they belong to the same genera as the cave-inhabiting arachnids, and often the species are so nearly allied that it would seem as if the same species might live both in caves and under the soil, and he thinks certain troglodyte arachnids may live also in porous soil. Several cave-inhabiting arachnids want eyes, such are *Anthrobia*, *Hadiles* and *Stalita*, but he thinks this is a character of minor importance, since it is owing to external conditions slowly produced after a series of generations. Thus M. Thorell has described a *Stalita Schiödtii*, which taken at the entrance of a cave, living in twilight, has rudimentary eyes, while the other species of the same genus living in total darkness has none. All the light-shunning arachnids, both troglodyte and hypogeal, have several features in common which show at once their kind of life. Their skin is thin, colorless, without the fine hairs usually clothing the body of other arachnids, but furnished here and there with long stiff hairs, which doubtless increase their sensitiveness. Their limbs are slenderer and longer than in their congeners living in the light, as has been noticed by American observers. Of this *Stalita* and *Blothrus* are striking examples, as these two arachnids belong to two groups represented respectively by *Dysdera* and *Obisium*, in which the limbs are short and stubby. These long appendages, adds M. Simon, thus modified, are perfectly adapted to a life in the dark; the slender, long feet, garnished with stiff hairs, are organs of a delicate sense of touch, which make up for the absence of eyes. The large fingers (cheliceres) are organs of distant prehension, which enable the species of the genus *Cyphophthalmus* (remotely

allied to the harvestmen) to detect at a distance prey, which they are unable to pursue, while the nearest allied external form is a species of Trogulus in which the appendages of the head are so short, that a slight advance of the front suffices to cover them. Here we see specific and generic characters induced by differences in the conditions of life, that are patent to the most casual observer. Hence the most telling facts for the theory that the different forms of life are induced by changes in life and the environment of the plant or animal, are afforded by cave animals. Our country abounds in such cases, and it is hoped that naturalists will explore them thoroughly, as many novelties may be expected.

Digestion in Insects. — M. Plateau finds that when the salivary glands of insects are not diverted from their primitive function to become silk or poison glands, they secrete a neutral or alkaline liquid, possessing at least as regards one pair, the property characteristic of the saliva of vertebrate animals of rapidly transforming starch matters into soluble and assimilable glycose. The change is effected in a posterior dilatation of the œsophagus. At this place results in the carnivorous insects a transformation of albuminous matters into soluble substances like peptone, and in vegetable-feeding species an abundant production of sugar out of the starchy matter eaten. When digestion has taken place in the œsophagus it is submitted to an energetic pressure in the gizzard or proventriculus which is armed with teeth. It thus seems that this is not an apparatus for crushing the food, but for expressing the liquid from the food triturated by the jaws. In the stomach, or middle intestine, as Plateau calls it, the food is again submitted to the action of an alkaline or neutral liquid secreted by local glands, present in the Orthoptera, or by a great number of small glandular cæca as in many beetles, or by a simple lining of epithelial cells. This fluid has no analogy with the gastric fluid of vertebrate animals. Its function differs according to the group to which the insect belongs. In the carnivorous beetles it makes an emulsion of the greasy matters; in the Hydrophilid beetles it continues the conversion of starch into glycose, begun in the œsophagus. In the caterpillars of the butterflies and moths it determines a production of glycose and makes an emulsion of greasy matters, and in the grasshoppers no sugar is formed in the intestine, as this material is produced and absorbed in the œsopha-

gus (*jabot*). The intestine proper is only a fœcal reservoir. The urinary or Malpighian tubes sometimes secrete calculi. No bile has been found in the secretions of these tubes. A point of great importance is touched upon by the author, namely: the passage of the chyle from the stomach to the blood. It is well known that there are in Articulates no lacteals as in Vertebrates to effect this process. Plateau states that the products of digestion pass through the walls of the digestive canal by an osmotic action and directly mingle with the blood.

Horny Crest on the Mandible of the Female White Pelican as well as the Male.— In all the standard works on the Birds of North America, it is stated that the horny crest or "button" on the upper mandible of the white pelican (*Pelecanus erythrorhynchus*) is exclusively a male appendage. I dissected, April 20th, 1875, an *adult female* of this species whose ovaries contained eggs in all stages of development. This bird was in full plumage, having the feathers of the head and breast conspicuously elongated and also having a *full-sized horny "button" on the upper mandible.*— F. H. Snow, *Lawrence, Kansas.*

The Western Nonpareil in Michigan.—On the 15th day of May last, Dr. H. A. Atkins of Locke, Ingham Co., Mich., shot and sent me a fine specimen, male, of *Cyanospiza versicolor*, which I have mounted and have now in my collection. Baird, Brewer, and Ridgway's "North American Birds" contains the following note on this species: "This beautiful species has only doubtful claims to a place in our fauna. It is a Mexican species and may occasionally cross into our territory. It was met with at Boquillo, in the Mexican state of New Leon by Lieutenant Couch. It was procured at Guatemala by Dr. Van Patten and by Salvin, and is given by Bonaparte as from Peru. It is also found at Cape St. Lucas, where it is not rare, and where it breeds."

It was shot in the vicinity of some Indigo birds, *C. cyanea*, on the first day of their appearance in this locality.—J. M. B. Sill, *Detroit, Mich.*

MICROSCOPY.

A new warm stage for the microscope.—Prof. E. A. Schafer of University College, London, finding the warm stages already

in use, such as Stricker's, described by Klein in Sanderson's Hand Book, to be clumsy and difficult to manage with precision, has contrived an apparatus which is moderately easy to prepare and use, and extremely precise in its results. It consists essentially of three parts, the stage, the hot-water reservoir, and the gas regulator.

The stage is a hollow brass-box, closed at every point except an inlet pipe at one end and an outlet pipe at the other. Through the centre of the stage is an opening or centre chamber for the transmission of light through the object. This chamber is closed above and below with cover-glasses, upon the upper of which the object rests. It communicates with the external air by a horizontal tubular opening through which a thermometer may be introduced to test temperature, or tubes for the introduction of gases or other reagents, but has no communication with the general cavity of the stage.

The reservoir consists of a vertical brass cylinder, containing hot water, which is heated by a gas flame below. From the top of this reservoir the hot water passes with a slight ascent through a flexible rubber tube to one end of the stage, through the length of the stage and back by a descending course through a rubber tube to the bottom of the reservoir. This is a closed circuit entirely filled with water, the hot water rising on one side and the cooled water falling on the other, precisely as the water pipes in the kitchen stove or range heat the copper boiler which supplies the hot water pipes of our houses. The reservoir is made hollow for the reception of the gas regulator.

The gas regulator is not unlike a thermometer with the top of the tube broken off. A steel tube with a narrow slit in one side is cemented tightly into the top of the glass tube of the regulator, and delivers the gas inside of the glass tube and some distance below its upper end. The glass tube has a side opening above the level of the bottom of the steel tube, from which the gas is carried by a flexible tube to the burner beneath the reservoir. The regulator is filled with mercury which, when the required temperature has been attained, is adjusted so as to just touch the bottom of the steel tube, the flame below the reservoir being only preserved by the gas which escapes through the slit in the steel tube, but the

least decrease in temperature allowing the mercury to fall and the more freely escaping gas to increase the flame. The adjustment of the mercury to the exact height required is accomplished by a screw which works through a steel collar on the side of the glass tube and which by working in or out gives the requisite change of capacity to the reservoir. This adjusting screw is the most difficult part of the apparatus for construction by an amateur, and may be omitted, the adjustment being accomplished by sliding the steel tube up or down until its lower end just touches the mercury after the desired temperature has been reached, in which case it, of course, is not cemented into the glass tube but made to slide into it through an air-tight packing. The proximity of the objective probably reduces somewhat the temperature of the object, and if great exactness is essential, an additional current of hot water may be carried through a flexible tube which is coiled around the objective. The apparatus is described and figured in the "Quarterly Journal of Microscopical Science."

Cox's Turntable.—Miller Bros. of New York have made an improved form of this excellent contrivance, which is marked by its handsome iron stand and its careful adjustment of the centring movements. If the real convenience of this table were known its use would soon become general.

NOTES.

Messrs. Henry Holt & Co., New York, will publish in January "Life-Histories of Animals, including Man," by A. S. Packard, Jr., containing the papers which have appeared during the past year in the Naturalist, with additional chapters and some changes and additions.

NOTICE TO SUBSCRIBERS.

As announced in our last number, the *American Naturalist* will, after this issue, be published by Messrs. H. O. Houghton & Co., of Boston, Mass., the former proprietors having dissolved partnership. It will hereafter be edited by A. S. Packard, Jr., with the assistance of eminent men of science.

It is hoped that, from the substantial interest taken in the conduct of the magazine by kind friends, a new lease of life awaits it.

Much more matter, equivalent to over fifty pages, due to the increased size of the page, will be put in the next volume, and

several new departments added, while the magazine will be more popular in character than of late.

The January number, with an attractive table of contents, will be sent out to past subscribers, and it is earnestly hoped that all will give the next volume a trial, and induce others to subscribe.

BOOKS RECEIVED.

Om Skuringsmærker, Glacial formationen, Terrasser og Strandlinier samt om grundfjeldets og sparagmitfjeldets mægtighed i Norge. By Theodor Kjerulf. II, Sparagmitfjeldet. Christiania, 1873. 4to.

The Land and Fresh Water Shells of La Salle County, Illinois. By W. W. Calkins. Chicago, 1874. Proceedings of the Ottawa Academy of Natural Sciences. pp. 48. 8vo.

Catalogue of Land and Fresh Water Shells. W. W. Calkins. Chicago, 1874. pp. 11. 8vo.

Bulletin de la Societe Geologique de France. 3me Serie, 3me Tome, No. 4. Paris, 1875.

Die Aegyptischen Denkmaler in St. Petersburg, Helsingfors, Upsala und Copenhagen. By J. Lieblein. Christiania, 1873. pp. 82. 8vo.

Enumeratio Insectorum Norvegicorum, Fas. 1. By H. Siebke. Christiania, 1874. pp. 72. 8vo.

The Third Annual Report of the Board of Managers of the Zoological Society of Philadelphia, 1875. pp. 33. 8vo.

Memoirs of the Geological Survey of India. Vol. i, Parts 2 & 3, and vols. ii-xi, 1. Calcutta. 8vo.

Palæontologia Indica. Series ii-x. 1. 4to.

Records of Geological Survey of India. Vols. i-vii. 8vo.

Society Entomologique de Belgique. Serie ii. No. 12, 13. 1875. 8vo.

The Journal of the Quekett Microscopical Club. London, March, 1875. No. 28. 8vo.

The Geological Magazine. London, May—Dec., 1875. Vol. ii. 8vo.

Tidsskrift for Populære Fremstillinger af Naturvidenskaben. Copenhagen, 1875. Vol. ii, Part 2. 8vo.

Grevillea. London, 1875. No. 28. 8vo.

Hardwicke's Science-Gossip. London. 1875. No. 126. 127. 8vo.

Field and Forest. Devoted to General Natural History.

Bulletin of the Potomac Side Naturalist's Club. Charles R. Dodge, Ed. Washington, 1875. Vol. i, No. 1. pp. 8. 8vo.

Circulars of Information of the Bureau of Education. Washington, 1875. Nos. 1 and 2. Pamphlets. 8vo.

Zoological Record for 1873. Vol. x. John Van Voorst. London. 8vo.

Seventh Annual Report on the Noxious, Beneficial and other Insects of the State of Missouri. By Charles V. Riley. Jefferson City, 1875. pp. 208. 8vo.

Eighth Annual Report of the Provost to the Trustees of the Peabody Institute of the City of Baltimore. Baltimore, 1875. pp. 43. 8vo.

Seventeenth Annual Report of the Board of Directors of the Mercantile Library Association of the City of Brooklyn. Brooklyn, 1875. pp. 24. 8vo.

Catalogus Specierum Generis Scolia. By Henricus de Saussure and Julius Sichel. Geneva, 1864. pp. 352. 8vo.

Circular No. 8, War Department, Surgeon-General's Office. A Report on the Hygiene of the United States Army, with Descriptions of Military Posts. Washington, 1875. pp. 625. 4to.

Notice Biographique sur Edouard-Rene Claparede, par Henri de Saussure. 1873. pp. 28. 4to.

Bulletin de l'Institut National Genevois. Geneva, 1875. Tome xx. pp. 304. 8vo.

Zeitschrift fur die Gesammten Naturwissenschaften. By C. G. Giebel. Berlin, 1874. Band x. Heft 7-12. 8vo.

Bulletin Mensuel de la Societe d'Acclimation. Paris. No. 11, 1874. No. 1, 1875. 8vo. *I. Travaux des membres de la Societe, De l'Utilite d'Introduire la Sericiculture a la Nouvelle Caledonie.* By M. C. Raveret. Wattel.

Verhandlungen der k. k. Zoologisch Botanischen Gesellschaft in Wien. 1874. Band xxiv. pp. 696. 8vo.

The Monthly Microscopical Journal. London, 1875. June. 8vo.

Verhandlungen des Vereins fur Naturwissenschaftliche Unterhaltung zu Hamburg. By J. D. E. Schmelt, 1875. pp. 191. 8vo.

Revue Scientifique. Paris. No. 50, and 5th year, Nos. 1, 2. 4to.

Northwestern Wyoming, including Yellowstone National Park. 1873. By William A. Jones. Washington, 1875. pp. 337. 8vo.

Recollections of Sir Charles Lyell. Annual Presidential Address of Natural History Society of Montreal, for 1875. By Principal Dawson. pp. 8. 8vo.

On some new Fossil Ungulata. By E. D. Cope. pp. 8. 8vo.

Abstract of Results of a Study of the Genera Geomys and Thomomys: with addenda on the Osteology of Geomyidæ, and on the Habits of Geomys Tuza. By Elliott Coues. Washington, 1875. 8vo.

Some Observations on the Birds of Ritchie County, West Virginia. By William Brewster. Annals, Lyceum Nat. Hist. New York. 1875. 8vo.

The Geological and Natural History Survey of Minnesota. The Third Annual Report, for the year 1874. By N. H. Winchell. St. Paul, 1875. 8vo.

Geological Survey of Indiana, 1874. By E. T. Cox. Indianapolis, 1875. 8vo.

Exploration of the Colorado River of the West, 1869-72. By J. W. Powell. Washington, 1875. 4to.

Tables for the Determination and Classification of Minerals found in the United States. By James C. Foye. Chicago, Jansen, McClung & Co., 1875. 12mo, pp. 38. 75 cents.

Haskell Portfolio, October, 1875. Published by the New England Society of Orange, N. J.

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